UV TRON® DRIVING CIRCUIT C3704 User's Manual

Thank you for purchasing the compact UV TRON driving circuit C3704. Before using your unit, please be sure to read this manual carefully to ensure correct operation.

1. FEATURES

- By connecting the C3704 to a UV TRON (such as the R2868), it can be operated as a high-sensitivity ultraviolet sensor (as a flame detector for lighters, matches, etc. (flame length is about 25mm) at a distance of 5m or more).
- The circuit input stage is supplied with a constant-voltage IC, so that operation is possible over a wide range of power sources, from 10 to 30V.
- Employment of a UV TRON background cancelling circuit ensures error-free operation.

2. APPLICATIONS

- Flame detectors for lighters and matches
- Fire alarms
- Combustion monitors for burners
- Electrical discharge detection

3. EXTERIOR DIMENSIONS

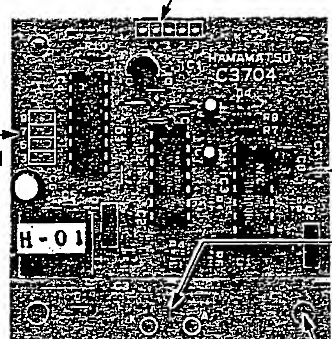
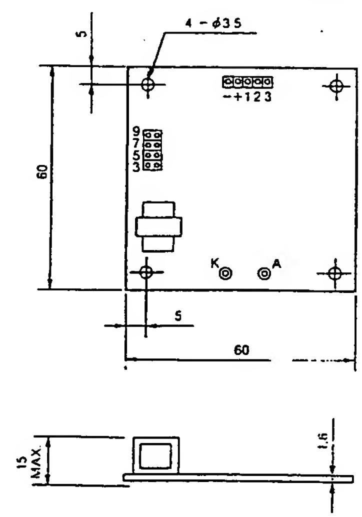


Figure 1: Diagram of Dimensions (unit: mm)



4. SPECIFICATIONS

Dimensions	60 (W) x 60 (D) x 15 (H) mm
Weight	Approx. 20g
Input voltage	DC 10 to 30V
Current consumption	3mA typical (with DC 24V power source)
Signal output	Open collector output (30V, 100mA max.) 10ms pulse width (Note 1)
UV TRON applied voltage	DC 350V (Note 2)
Operating temperature range	−10 to +50°C (with no condensation)
Applicable UV TRONs	Types with discharge starting voltage of 300V or less. (R2868, R1753-01, R259, etc.)

Note 1: By adding a condensor to the PCB, the output pulse width can be extended up to about 100 seconds. Refer to 6. Operation.

Note 2: Since the output impedance of the power source is extremely high, the voltage cannot be measured with an ordinary voltmeter. Use a measuring device with an input impedance of 10GΩ or more.

5. CONNECTIONS

1) Connecting the UV TRON

As shown in Figure 2, the UV TRON should either be soldered directly to the circuit board, or connected with a short lead wire of 5cm or less.

● **CAUTION**

◇ The UV TRON is a precision component made of glass. Be careful not to drop it or subject it to sharp impact, as this may cause a deterioration of its performance. Handle it very carefully.

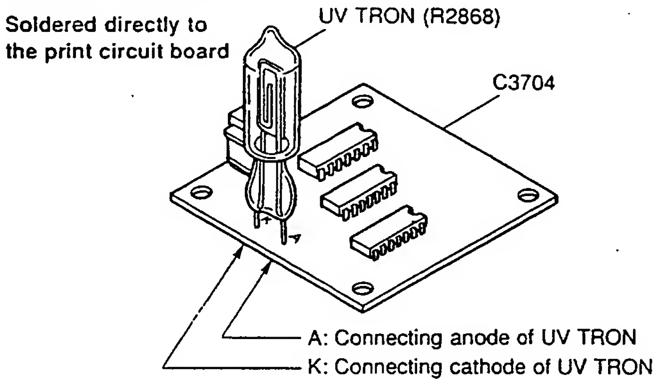
◇ The UV TRON is a bipolar phototube. Be sure to connect it correctly, referring to the data sheet. Incorrect or reversed connections may lead to erroneous operation.

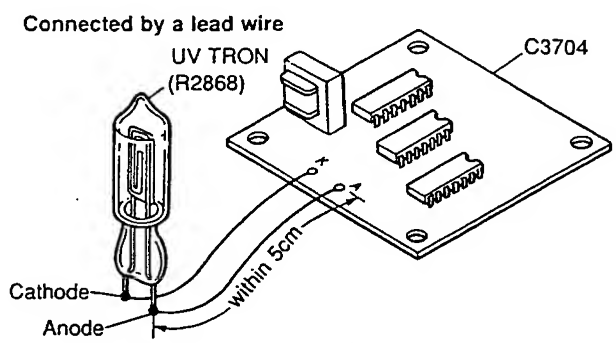
◇ Soldering should be done quickly within 5 seconds, at 300°C or below. If too much heat is applied to the lead wire, the glass may crack, leading to deterioration of performance.

◇ After soldering, excessive flux should be removed with alcohol. If any dirt or flux remains, humidity may cause an electrical leak, resulting in a voltage drop to the UV TRON. This could cause a decrease in sensitivity and a loss of operation.

◇ It should be noted that the glass may be broken if the UV TRON lead wire is installed with too much force. When bending the lead wire, fix the end of the wire on the glass side with pliers to prevent force from being applied onto the glass.

Figure 2: Connecting the UV TRON





Solder the lead wire (within 5cm), using a Teflon lead wire with good insulation.

2) Connecting the Power Source and Signal Output

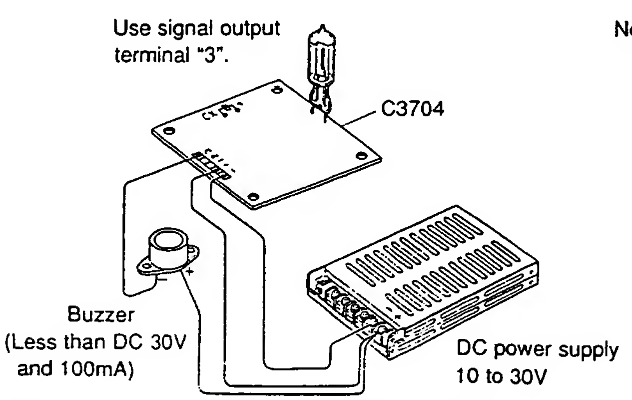
Refer to figure 3, 4 or 5, depending on your purpose, for connecting the power source and signal output.

● **CAUTION**

◇ It is very important not to reverse the + and - terminals of the power source. If they are connected in reverse, the IC in the circuit may be damaged, making operation impossible.

◇ Signal outputs 1 and 2 are output directly by the C-MOS IC. If the GND and power source are accidentally shorted, the IC in the circuit may be damaged, making operation impossible.

Figure 3: When Connecting a Buzzer

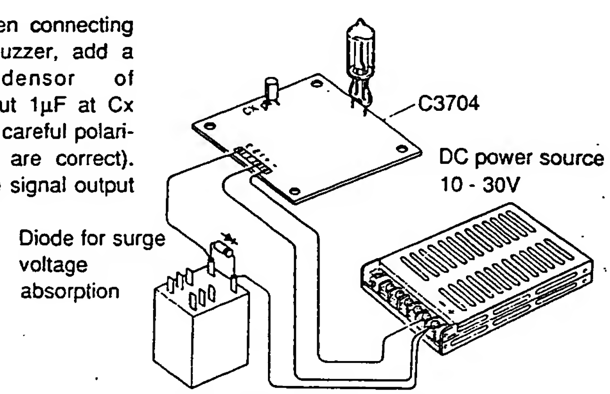


The buzzer sounds when ultraviolet light enters the unit.

(The length of time for which the buzzer sounds can be extended by adding a condensor at Cx on the PCB. See Figure 6.)

Figure 4: When Connecting a Relay

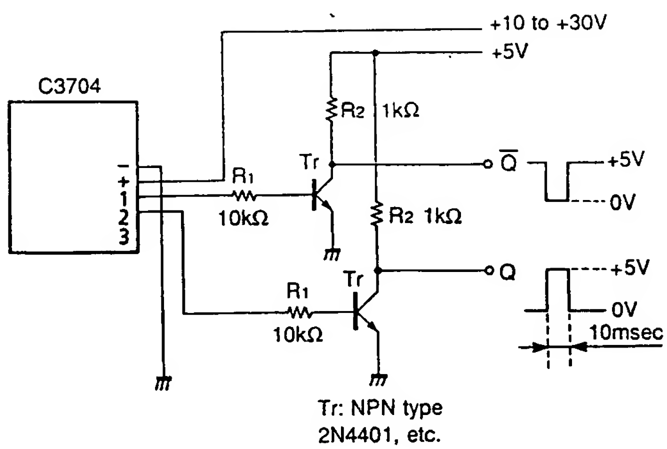
Note: When connecting a buzzer, add a condensor of about 1μF at Cx (be careful polarities are correct). Use signal output "3".



Relay (Coil rating: 30V max., 100mA max.)

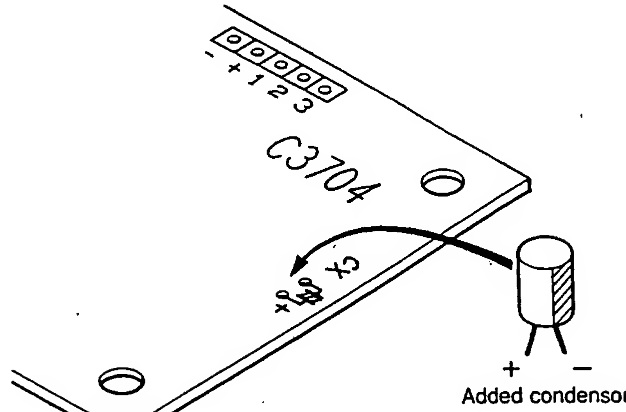
Note:
No surge voltage protector circuit is added to the output transistor of the C3704. When connecting an inductive charge such as a relay, connect a surge voltage absorption diode to both ends of the relay coil, as shown in the illustration. (Be careful not to reverse the polarities.)

Figure 5: Connecting a TTL IC



Note: Q and Q̄ are reversed when the Tr is introduced.

Figure 6: Adding a Condensor to Extend the Output Pulse Width



Note: Electrolytic condensors are bipolar. When attaching this kind of condensor, connect the + side of the condensor to the + mark on the PCB.

6. Operation

Operation of the C3704 will be explained assuming the UV TRON is an R2868. When another UV TRON is used, operation is basically the same, but since the sensitivity level differs depending on the UV TRON used, detection times may vary also. For details, please refer to the data sheet.

Operation is explained in the order shown on the Time Chart in Figure 7.

① If ultraviolet light is introduced into the UV TRON, a pulse width of 10µs is output. The generated frequency of this signal pulse varies depending on the amount of incident ultraviolet light.

② Also, when no ultraviolet light is present, sporadic pulses ranging from several times to several tens of times per hour are generated by cosmis rays, static electricity, etc. This is called background (BG).

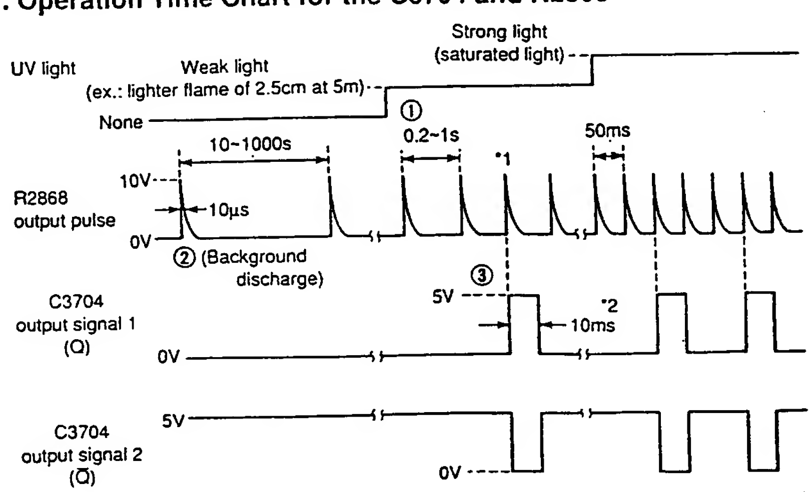
③ The pulse waveforms of the signal and the BG are exactly the same, making it impossible to differentiate between them. Because of this, the generated frequency of the pulse is carefully observed to distinguish the signal from the BG, and the BG only is cancelled. (If the signal pulse of the UV TRON is directly output, erroneous operation may result, depending on the BG. It is necessary to have a means of differentiating the BG from the signal of the incident ultraviolet light, to extract only the signal.)

The BG cancel circuit of the C3704 outputs signal pulses of 10ms width only when three consecutive pulses (*1) enter the circuit with a time interval of 2 seconds or less from the UV TRON.

*1: The number of pulses can be specified in four stages, 3, 5, 7, and 9, by means of a jumper wire on the circuit board. This is set to "3" at the time of shipping, but if there is too much background, the cancel background can be set to a higher level (5, 7, 9).

*2: The pulse width can be extended by adding a condensor to the Cx terminal on the circuit board. See Figure 6. (For example: Cx = 1µF Pulse width = approx. 1 second, Cx = 10µF Pulse width = approx. 10 seconds)

Figure 7: Operation Time Chart for the C3704 and R2868



For more detailed information regarding the UV TRON, please feel free to request the technical data sheets and catalogs available from Hamamatsu.

7. Precautions Concerning Use

- The C3704 uses a C-MOS IC. Be very careful about external noise. It is recommended that the entire PC board be placed in a metalcase.
- The DC-DC converter-type high-voltage power supply used in the C3704 has an extremely high output impedance. If the surrounding humidity is high, electrical leakage from the PC board surface may lead to a drop in the supply voltage to the UV TRON. This voltage drop may result in lowered detection performance, so a moistureproof material (silicon compound, etc.) should be applied to the UV TRON contact point if the unit is to be used in a humid environment.
- If there is oil or another substance on the glass surface of the UV TRON, the permeability of the ultraviolet light is decreased, lowering sensitivity. In this case, clean the surface carefully with a piece of gauze dipped in alcohol to remove any residue.
- The UV TRON is a precision component made of glass. Be careful to protect it with a buffering material against vibration or impact even after it has been assembled.

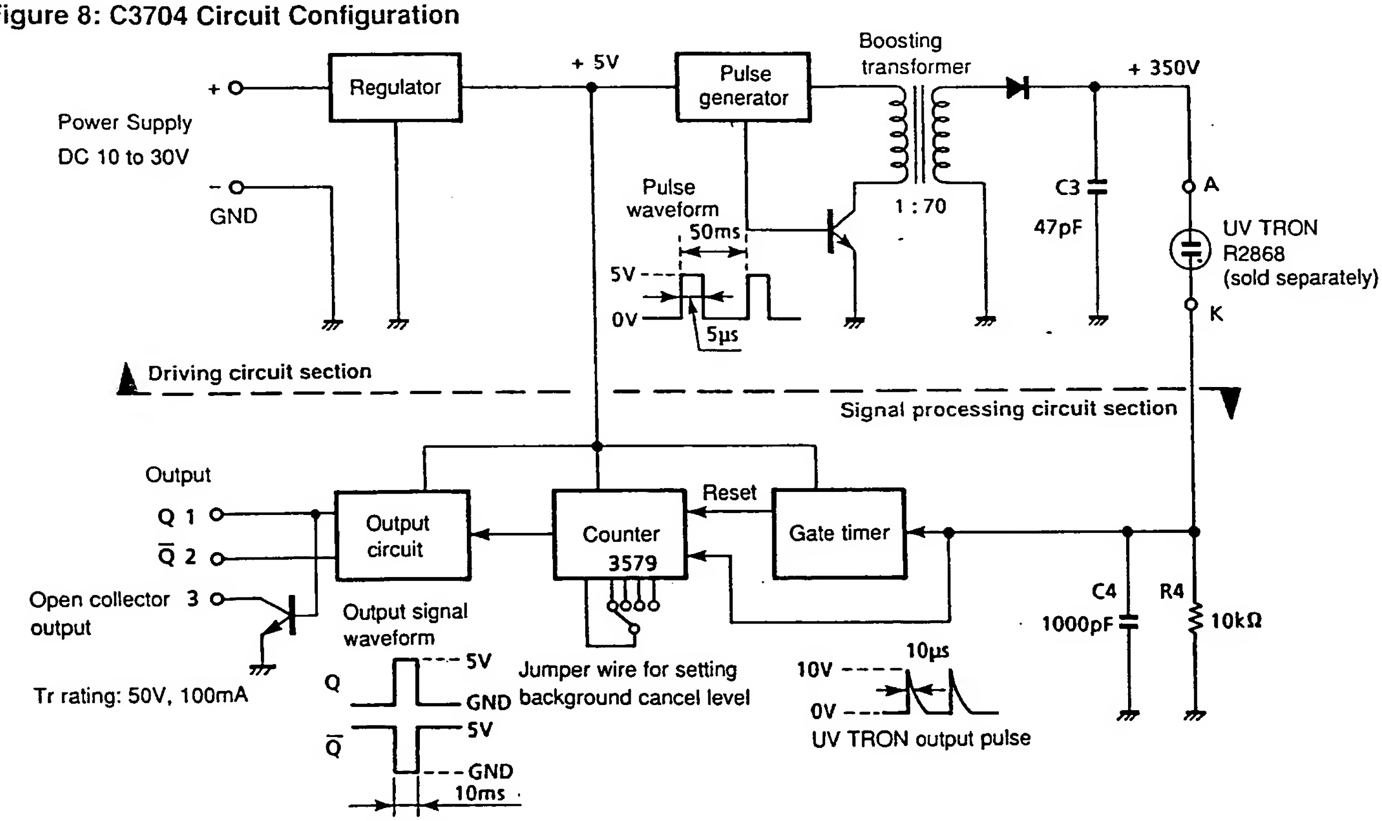
8. Warranty

The period of warranty is one year after the date of delivery. During this period, if any damage is judged to be the fault of Hamamatsu, the unit will be repaired or replaced at no charge.
Damage occurring because of failure to follow the instructions in this manual, or if any unauthorized additions were made to the unit by the user, or damage resulting from natural disasters, will not be covered by this warranty.

9. After-Service

This unit was manufactured and inspected under the strictest quality conditions. In the rare event that damage should occur, please contact Hamamatsu directly (or arrange direct delivery of the unit to us). At that time, please describe the content of the breakdown or damage in as much detail as possible, and include the information with the product itself.

Figure 8: C3704 Circuit Configuration



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TECHNICAL INFORMATION

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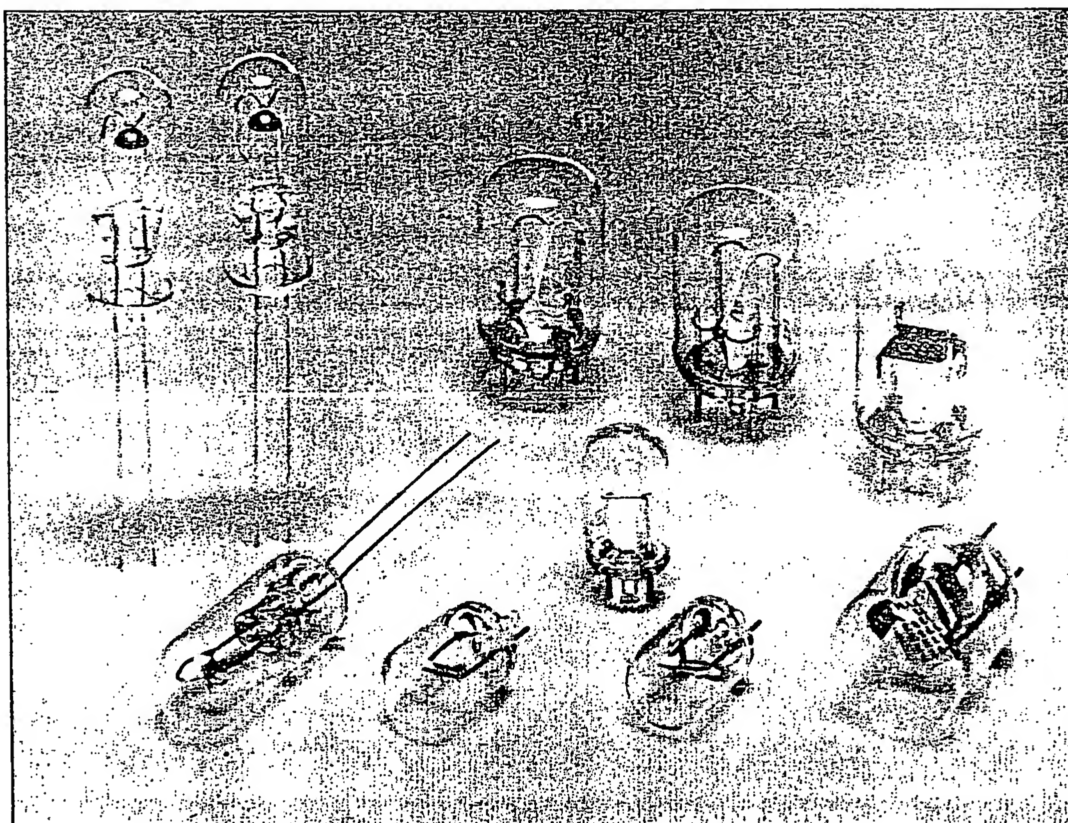
UVtron®
(Ultraviolet Detector Tube)

Characteristics and Methods of Use



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ATTACHMENT 3

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UVtron® (Ultraviolet Detector Tube)

Characteristics and Methods of Use

INTRODUCTION

Fire detection and the monitoring of combustion is usually accomplished by the use of sensors to detect temperature, smoke, light, etc. But the response speed of conventional temperature and smoke sensing methods is low, and visible or infrared detectors require additional devices to prevent false alarms due to background sunlight, room illumination, or excessive heat from fireplace walls.

A high speed response in the detection of flames, without the interference of other light, is possible due to UVtron's high sensitivity to ultraviolet rays.

The major features and applications of UVtrons as well as the operational principles, characteristics, and methods of use will be described in detail in the following paragraphs. We recommend that they be adhered to insure satisfactory results.

Fig. 1 shows the spectral distributions of a gas burner flame, a tungsten lamp, and the sunlight on the earth's surface and the spectral response of UVtron. From this figure, we can see that UVtron sensitivity is restricted to a very narrow region of ultraviolet rays, and exhibits no response at all in the visible region.

Typical Applications

- Combustion monitoring apparatus for gas and oil burner
- Fire alarm apparatus
- Photoelectronic counter
- Detection of ultraviolet ray leakage
- Detection of discharge phenomenon

Features

- Capability of detecting very weak ultraviolet rays (from 1 pW)
- Not sensitive to visible and infrared light (solar blind characteristics)
- High reliability and long service life (over 10,000 hours of continual discharge operation)
- High speed response (less than a few milliseconds)
- Miniature size and lightweight

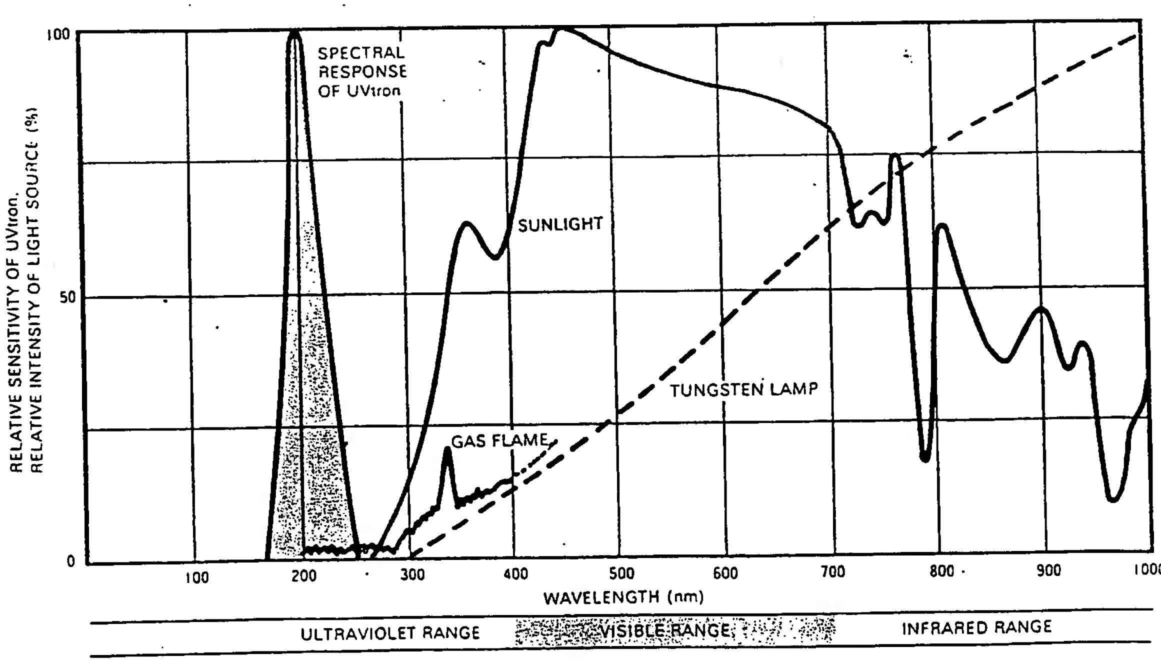


Fig. 1 Various spectral distributions

STRUCTURAL OUTLINE

UVtron is a gas discharge tube in which discharge is induced by ultraviolet rays. As shown in Fig. 2, it is comprised of a glass bulb through which ultraviolet rays can enter. It contains a pair of electrode (anode and cathode) and a special gas.

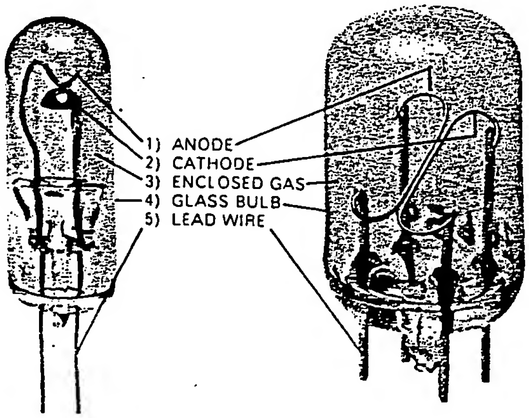


Fig. 2 Description of UVtron

1) Anode:

The positive voltage applied to this electrode creates an electric field between anode and cathode.

2) Cathode:

This electrode is made of metals which are able to emit photoelectrons when exposed to ultraviolet rays. A negative voltage is applied to the cathode.

3) Enclosed gas

The photoelectrons emitted from the cathode are accelerated towards the anode by the electric field and collide with the enclosed gas molecules which are ionized. This ionization increases the number of charges which in turn creates a large current.

4) Glass bulb

The bulb is made of glass through which ultraviolet rays can pass. UV glass and fused silica are available depending on the transmittance characteristics for ultraviolet rays (see Fig. 3).

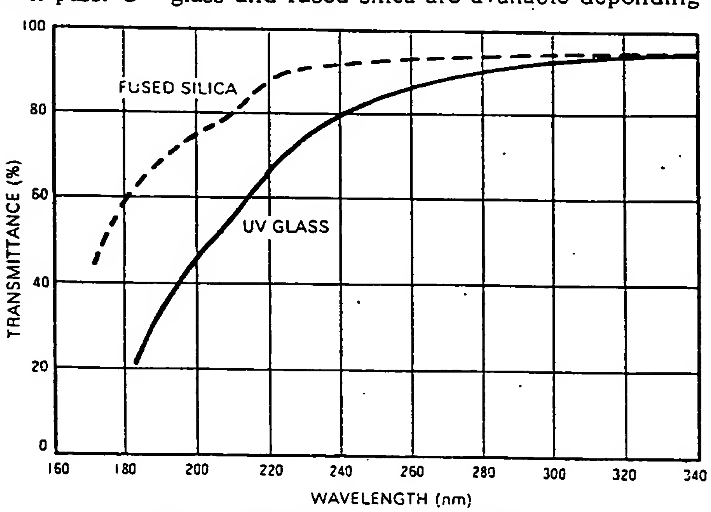


Fig. 3 Transmittance of glass

5) Lead wire

Flexible leads and hard pins are available. A plastic base can be attached to the flexible leads on request.

PHOTOELECTRIC EMISSION AND ELECTRODE MATERIAL

The phenomenon consisting of the excitation of electrons in a metal by incident light, and their emission into vacuum is called external photoelectric effect; emitted electrons are called photoelectrons. The relation between the photoelectron kinetic energy E and the incident light frequency ν is given by the following expression:

$$E = h\nu - W \quad \text{..........(1)}$$

h: Plank's constant
W: Work function

Electrons can be emitted only if their kinetic energy is positive. Therefore, the threshold frequency ν_0 for external photoelectric effect is obtained by putting $E = 0$ in the expression (1).

$$\nu_0 = \frac{W}{h} \quad \text{............(2)}$$

The threshold wavelength λ_0 (cut-off wavelength) corresponding to ν_0 is obtained by using the $\lambda = c/\nu$ (λ = wavelength, c = velocity of light).

$$\lambda_0\ (\text{nm}) = \frac{hc}{W} \simeq \frac{1240}{W\ (\text{eV})} \quad \text{........(3)}$$

Therefore, in order for the cathode to have sensitivity only for ultraviolet rays with a wavelength shorter than 300 nm, the cathode material should be a metal having a work function higher than 4.1 eV. There are various metals which satisfy this condition. Taking into account the processing, availability, and the price of the metal, the following three metals are usually employed.

1) Ni (Nickel)

As this metal can be easily obtained and processed, it constitutes a very good electrode material. It is ideally suited for fire alarm use because of its relatively high work function (about 5.0 eV) and good solar blind characteristics. However, because of the metal's softness, the electrode is susceptible to fatigue due to discharges. Therefore, it is not suitable for burner monitoring where UVtrons are used in a continual discharge operation.

2) Mo (Molybdenum)

Since this metal is harder than Ni, it is more resistant to vibrations, and the fatigue factor of the electrode surface is less. The work function is about 4.1 eV and the cut-off wavelength becomes 300 nm. Hence, it is suitable for burner monitoring application where the exterior light (such as sunlight) does not enter directly.

3) W (Tungsten)

The work function for tungsten is about 4.5 eV. The cutoff wavelength is between Ni and Mo. This metal is harder than Mo, therefore, even if the discharge current is increased, electrode fatigue is almost nil. Thus direct relay driving is possible and as a result this material is suitable for burner monitoring.

Fig. 4 shows the spectral response characteristics of UVtrons with the above mentioned cathode materials. The short wavelength cut-off is controlled by the transmittance characteristics of the glass bulb shown in Fig. 3.

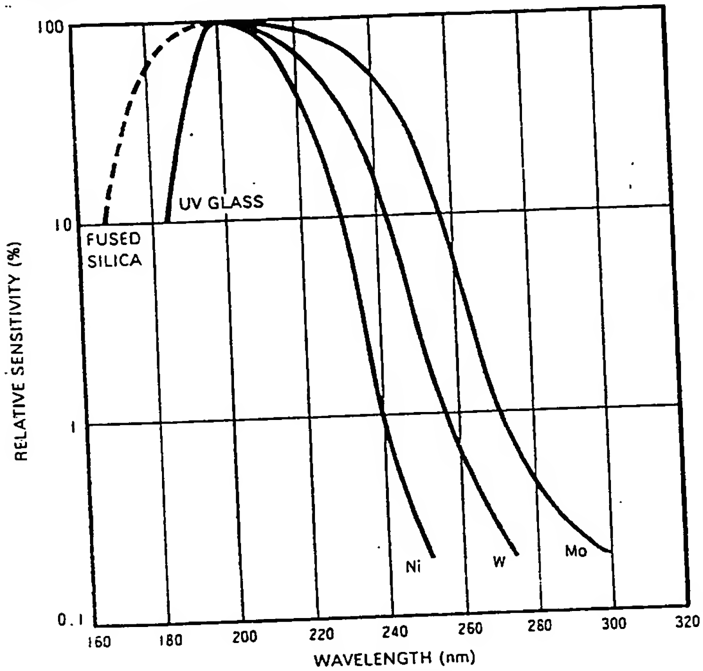
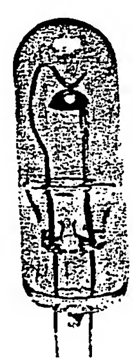


Fig. 4 Spectral response characteristics of UVtron

ELECTRODE SHAPE AND DIRECTIONAL CHARACTERISTICS

UVtron electrodes are classified into the following three types according to the different discharge forms. The electrode shapes should be selected according to their specific application as the shape is an important factor deciding the sensitivity and directional characteristics.

1) Point Discharge Type



This type has a small facing area on the electrodes resulting in directional characteristics (shown in Fig. 5 (a) that take precedence over sensitivity. In addition, the extinguishing time (see page 7) is short, and the operation is stable over a wide range of temperatures. Therefore, this type is suitable for many applications.

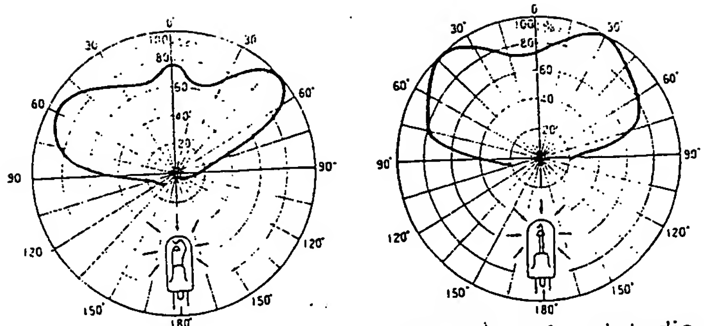


Fig. 5(a): Directional characteristics of point discharge type (R259)

2) Line Discharge Type

The electrodes of this type are comprised of two parallel wires so designed as to provide a larger facing area. The line discharge type emphasizes the importance of the sensitivity rather than the directional features. From the outside, it appears that the electrodes have no polarity. However, the anode and the cathode are made by different processes and they should be used with the correct polarity of the applied voltage.

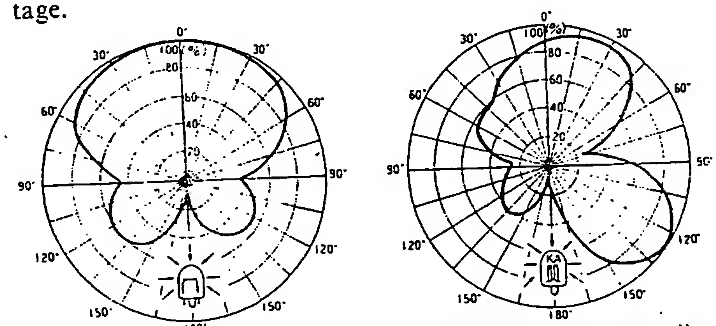
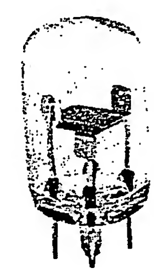


Fig. 5(b): Directional characteristics of line discharge type (R1490)

3) Surface Discharge Type



The electrodes of this type are comprised of two parallel plates resulting in a wide facing area. The anode is in mesh form to reduce the shadow on the cathode. The sensitivity of this type is 10 times larger than the point discharge type.

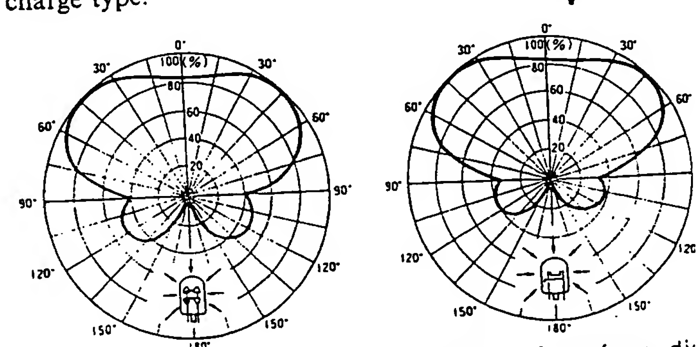


Fig. 5(c): Directional characteristics of surface di: charge type (R1753)

OPERATIONAL PRINCIPLE

UVtron is a cold cathode discharge tube with a high sensitivity and high output power. The photoelectrons emitted from the cathode due to incident ultraviolet rays are multiplied by a gas discharge phenomenon.

To operate the UVtron correctly, it is necessary to understand the meaning of the following voltages.

1) Discharge Starting Voltage V_L

Fig. 6 shows the basic connection for UVtron. When the source voltage E_{bb} is gradually increased and the cathode exposed to ultraviolet rays, photoelectrons are emitted from the cathode by photoelectric effect and then accelerated towards the anode by the electric field. As the applied voltage becomes higher and the electric field stronger, the kinetic energy of the electrons becomes large enough to ionize the molecules of the enclosed gas by collision. Electrons and positive ions are generated. The electrons generated by ionization are accelerated, enabling them to ionize other molecules before reaching the anode. On the other hand, positive ions are accelerated forwards the cathode and collide with it, generating secondary electrons. This avalanche process causes a large current between the electrodes and discharge takes place. The voltage at which discharge occurs is called the "discharge starting voltage V_L".

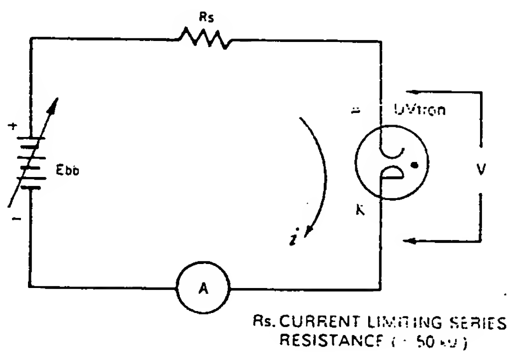


Fig. 6 UVtron basic connection diagram

2) Discharge Sustaining Voltage V_S

Once the discharge occurs, the tube is filled with electrons and ions. The voltage drop between the cathode and the anode is considerably reduced as compared to the condition before discharge as shown in Fig. 7.

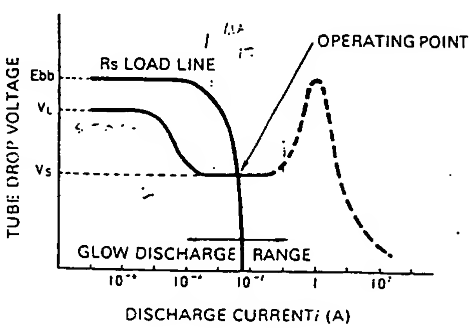


Fig. 7 UVtron V-I characteristics

The current limiting resistance R_S shown in Fig. 6 is indicated by the load line shown in Fig. 7. The point of intersection between R_S load line and the V-I curve is the operating point of UVtron in this circuit. The tube drop voltage at the intersection point is called "discharge sustaining voltage V_S", and is given by the following expression.

$$V_s = E_{bb} - R_s \cdot i \quad \text{.........(4)}$$

(The discharge sustaining voltage V_S shown in the characteristic table corresponds to $i = 2$ to 4 mA)

If the operating point of the UVtron is within the glow discharge range, V_S is lower than V_L. Therefore, once the discharge commences, it continues as long as the applied voltage is greater than V_S.

The schematic diagram of the relation between the applied voltage and the discharge current is shown in Fig. 8.

3) Breakdown Voltage V_B

If the applied voltage is progressively increased in the absence of ultraviolet rays, discharge can not start even if the voltage is greater than V_L because no photoelectrons are present. However, if the voltage is increased further, breakdown occurs at a certain voltage V_B and the discharge takes place. (In this case, discharge continues until the applied voltage is reduced to V_S, as shown in Fig. 8.)

The breakdown voltage is usually larger than 1000 volts. Never apply such a high voltage to UVtron.

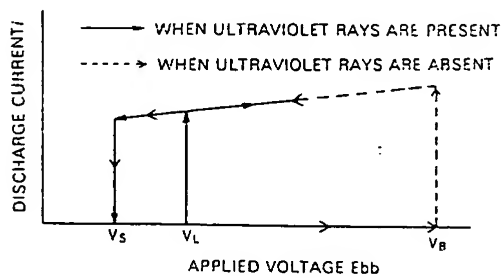


Fig. 8 UVtron operating characteristics

✻QUENCHING CIRCUIT

As shown in Fig. 6, once UVtron discharge begins, it will be in a self-maintained discharge mode and, as such, cannot detect ultraviolet rays properly. This is because the UVtron does not have self-quenching properties. Therefore, an external quenching circuit is required.

To prevent a self-maintained discharge, it is necessary to periodically decrease the anode voltage to a value lower than V_S. This quenching can be achieved by two methods.

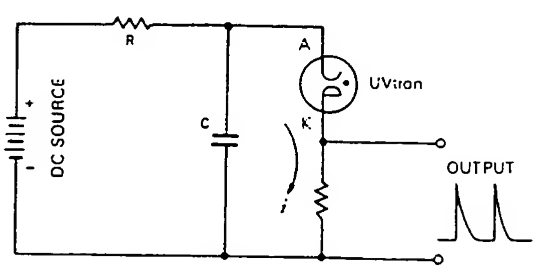


Fig. 9(a): CR quenching circuit

The first method uses a CR charging and discharging circuit as shown in Fig. 9 (a). The other method consist of applying pulsed voltage from a half-wave rectifier of line frequency. Please see the details in the driving circuit section.

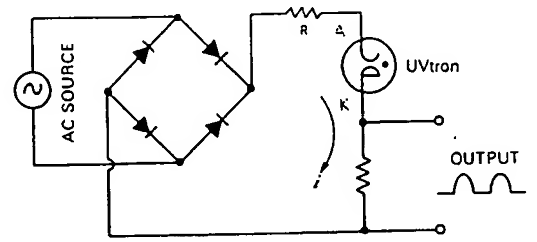


Fig. 9(b): Pulsed voltage quenching circuit

4) Discharge Stopping Voltage V_D

When the UVtron is connected to a quenching circuit, discharge occurs only if the applied voltage is larger than the discharge starting voltage V_L and if ultraviolet rays are incident. Discharge stops when ultraviolet rays are no longer present. However, when the applied voltage is increased to be nearer the breakdown voltage and if a discharge takes place, it will continue until the voltage is reduced slightly as shown in Fig. 10. This is due to the influence of residual ions (see page 7) generated by the discharge.

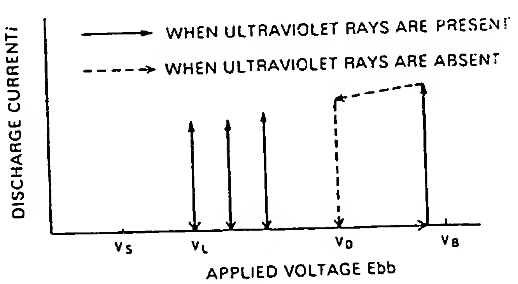


Fig. 10 UVtron operational characteristics

In this figure, the point V_D is called "discharge stopping voltage" and corresponds to the maximum voltage at which the UVtron can be normally operated with quenching circuits. Please keep in mind that the discharge stopping voltage V_D depends on many factors such as the quenching circuit constants and the surrounding temperature so that this voltage reflects a typical value related to the operating conditions rather than to UVtron characteristics.

5) Recommended Applied Voltage V_R

According to the above characteristics, we have understood that the applied voltage should be between the discharge starting voltage V_L and the discharge stopping voltage V_D. However, there exists an trade off between them: near V_L the sensitivity is low and near V_D the background influence (see page 10) increases. Therefore, to obtain optimum characteristics, a suitable voltage range is recommended.

A general concept of the voltages described above from 1) to 5) is illustrated in Fig. 11.

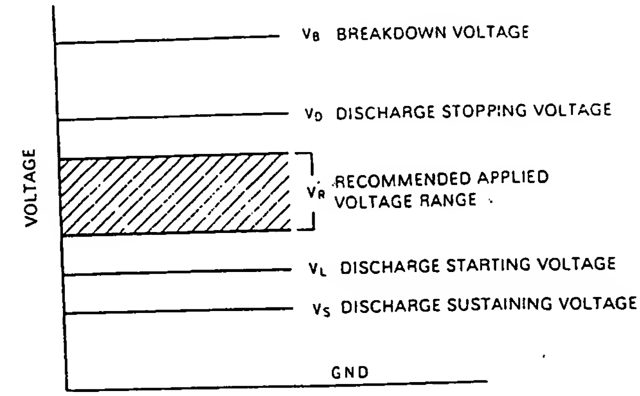


Fig. 11 General concept of UVtron operating voltage

DRIVING CIRCUIT

1. PULSE DRIVEN CIRCUIT USING CR

This circuit is suitable for a high voltage DC source which is achieved by the use of a DC-DC converter from a low voltage DC source such as a dry battery, etc.

The UVtron can be operated at a very small current. Since DC voltage is applied to the UVtron, detection is possible at any time. Its application in a fire alarm circuit would provide a high speed response.

The general circuit and operating waveforms are shown in Fig. 12. The operation and function of this circuit will be explained in the same figure.

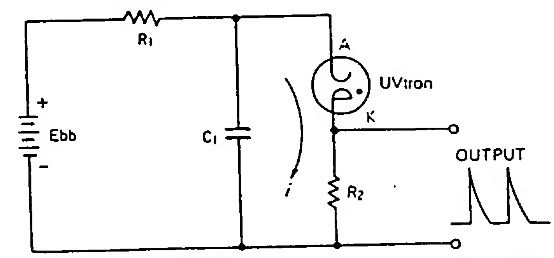


Fig. 12(a): Pulse driven circuit using CR

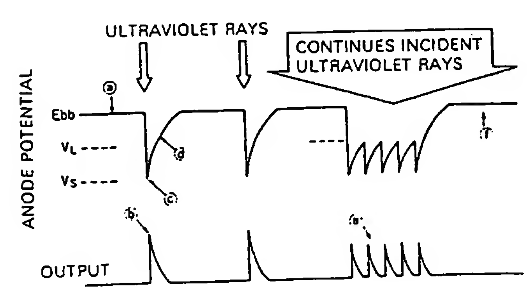


Fig. 12(b): Operating waveforms of each part

Point "a" ..... When ultraviolet rays are absent, UVtron does not discharge, and there is no current flow between the anode and the cathode. Therefore, the anode potential is the same as the applied voltage E_{bb}.

Point "b" ..... Ultraviolet rays are incident and they cause a discharge. The discharge current is mainly supplied by the charged capacitor C_1, which gives rise to a momentary current flowing through R_2. As a result, a narrow pulse voltage is generated across R_2.

Point "c" ..... If the charge on C_1 decreases, the anode potential alos decreases until it becomes lower than the discharge sustaining voltage V_S, and the discharge stops temporarily.

Point "d" ..... When the discharge stops, the capacitor C_1 becomes charged from the source E_{bb} through R_1, and the anode voltage of UVtron increases once more.

Point "e" ..... When anode voltage reaches the discharge starting voltage, the UVtron once again discharges and generates a pulse if the ultraviolet rays are continuously incident.

Point "f" ..... If the ultraviolet rays are absent, the anode potential returns to the source voltage, and discharge does not occur until the next incidence of ultraviolet rays.

By repeating this process, the UVtron is quenched and the presence of ultraviolet rays is detected as pulse signal output.

1) Quenching Time t_q and Extinguishing Time t_x

Let us think about the time constant $C_1 \cdot R_1$. After a discharge occurs in UVtron, the capacitor C_1 is charged through R_1 and the anode voltage increases to the starting voltage V_L. The time t_q (quenching time) required for that process is given by the following expressions.

$$t_q = C_1 \cdot R_1 \cdot \ln \frac{E_{bb} - V_S}{E_{bb} - V_L} \quad \text{......(5)}$$

Note: If E_{bb} is the recommended voltage, then:

$$\ln \frac{E_{bb} - V_S}{E_{bb} - V_L} \doteqdot 0.5$$

Within this time t_q, the UVtron cannot discharge.This is very important feature of DC source circuits.

When a discharge occurs in UVtron, a large number of positive ion are generated and remain suspended between the electrodes even after the discharge has stopped. If the anode voltage rises once again before these ions are neutralized, they are accelerated towards the cathode, bombarding it and giving rise to secondary electrons which can induce discharge even in the absence of ultraviolet rays.

These ions are called "residual ions"; the time t_x required for the ions to be neutralized is called "extinguishing time".

This time t_x depends on the surrounding temperature and the value of the dischrge current. It is important to make t_q sufficiently longer than t_x while determining the circuit constant $R_1 \cdot C_1$ in order to obtain a stable UVtron operation.

Next, let us consider the value of R_2 connected at the cathode and converting the discharge current into a pulse voltage. If the value of R_2 is small, the discharge current vanishes rapidly. This is a very important factor for the quenching operation. In Fig. 12, at every discharge, the charge of C_1 supplies the discharge current. At this time, it is important to set the operating point of UVtron within the glow discharge range as shown in Fig. 7 of the operating principle section. If the value of R_2 is large, glow discharges cannot occur and the internal impedance of UVtron cannot decrease. Therefore, the charge of capacitor C_1 cannot decrease sufficiently, and the quenching operation will be unstable.

Conversely, if the value of R_2 is too small, a large current flows momentarily and the electrodes can be damaged.

Please select R_2 between 5 and 50 kΩ.

2) Discharge Current *i* of CR Driving Circuit

Average discharge current *i* flowing through the UVtron, in accordance with the charge Q_1 supplied from C_1 and the number of discharges per second f, can be expressed as follows:

$$i = f \cdot Q_1 \; ; \; Q_1 = C_1 \cdot (V_L - V_S)$$
$$\text{then, } i = f \cdot C_1 \cdot (V_L - V_S) \quad \text{.......(6)}$$

In continuous incident light operation, the number of discharges per second f, reaches its maximum value which is equal to $1/t_q$. Therefore, the maximum current (the maximum value of average current) i_{max} in this circuit can be calculated by the next expression:

$$i_{max} = \frac{1}{t_q} \cdot C_1 \cdot (V_L - V_S) \quad \text{...........(7)}$$

Since average discharge current *i* directly affects the service life of UVtron, consider this point carefully while defining the various constants.

3) Recommended Circuit Constants

To get suitable values of discharge current *i* and quenching time t_q in Fig. 12 (a), the range of various constants should be as follows:

R_1: 5MΩ to 50MΩ
C_1: 50pF to 500pF
R_2: 5kΩ to 50kΩ

The minimum value of quenching time $t_q (\doteqdot 0.5 \cdot C_1 \cdot R_1)$ is determined in accordance with the specific type of UVtron to be used. Therefore, select the value of C_1 and R_1 so that the quenching time becomes larger than the minimum values specified in the characteristics table. For example, recommended driving circuits of R259 and R1490, and their output waveforms are shown in Fig. 13.

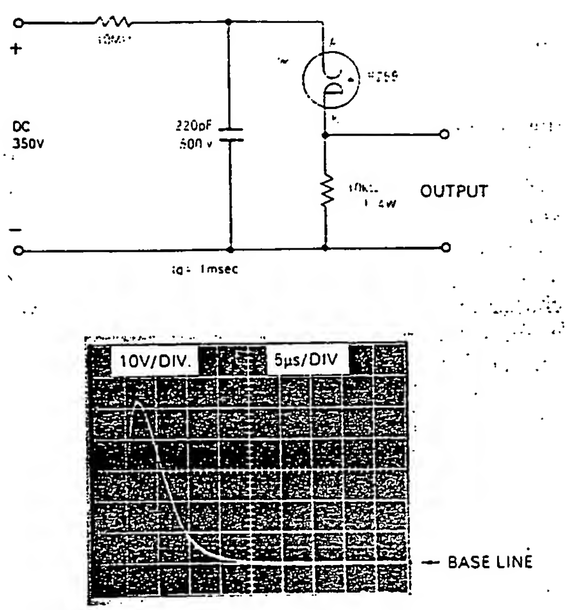


Fig. 13(a): Recommended circuit constants and output waveform of R259

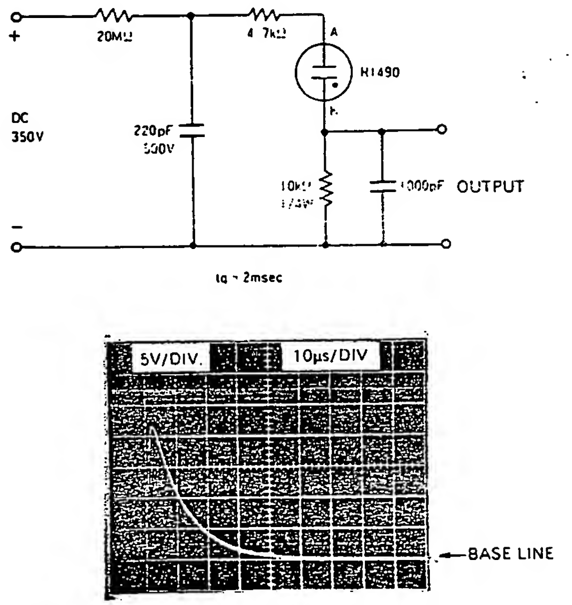


Fig. 13(b): Recommended circuit constants and output waveform of R1490

4) UVtron Wiring

In the pulse driven circuits using CR, the power source circuit, signal circuit, and UVtron should be as close as possible. It is ideal to wire them on the some printed circuit board.

When it is absolutely essential to separate the UVtron from the rest of the circuit, the cable stray capacitance C_S causes a discharge current i_S which does not contribute to the output signal (Fig. 14), and may cause damage to the UVtron electrodes. Therefore, if the cable capacitance is larger than 100 pF, connect a current limiting resistance R_S (1 to 5 kΩ) to the UVtron anode as shown in Fig. 14.

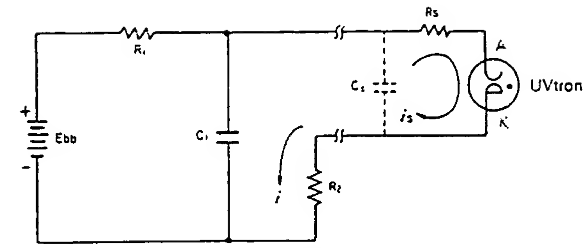


Fig. 14 When UVtron is separated from the rest of the circuit

2. DRIVING CIRCUIT USING PULSE VOLTAGE

In the pulse operation using CR, the UVtron is operated at a very small current due to the high resistance connected to the anode. In applications such as burner monitoring, it is necessary to separate UVtron from the electric circuits to protect them against the heat emanating from the fireplace. Also this is required for making a central monitoring system involving several UVtrons.

However, if the UVtrons are separated from the power source and the signal circuit by more than a few meters, low current operation is affected by external noise. In this case the circuit shown in Fig. 15 is used. The operation waveforms are shown in the same figure.

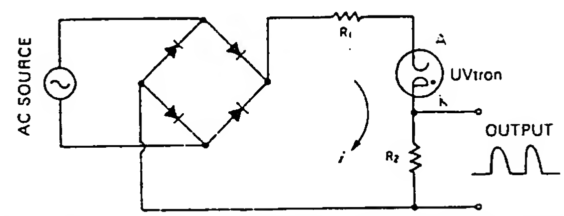


Fig. 15(a): Driving circuits using pulsed voltage

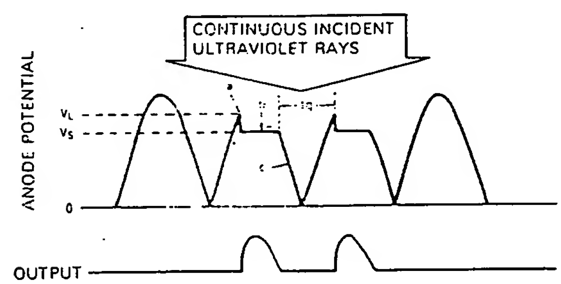


Fig. 15(b): Operation waveforms at each part

Point "a" ..... When the source voltage E_{bb} increases as a sine curve and becomes more than the firing potential V_L, then the discharge starts if the ultraviolet rays incident.

Point "b" ..... After the discharge, the anode voltage decreases to the discharge sustaining voltage V_S, and the discharge current i flows during this period.

Point "c" ..... Source voltage E_{bb} decreases sinusoidally and, when it becomes lower than the discharge sustaining voltage V_S, the discharge stops. Even if ultraviolet rays are incident, discharge will not occur until the voltage increases again to the discharge starting potential V_L.

If the pulsed voltage is applied in this way, then for full-wave rectification, the quenching condition will periodically exist at a frequency which is two times the source voltage frequency and the voltage will reach zero without fail. Therefore, UVtron can be quenched with absolute certainty.

1) Recommended Circuit Constants

When the pulsed voltage is applied, it is not necessary to consider the quenching time. The value of resistance $R_1 + R_2$ can be selected so as to allow the current i to be within the limits of the recommended current value of the UVtron. Therefore, the design of the driving circuit can be easily achieved.

The output signal from R_2 is a pulse and can be counted directly by a pulse counter circuit. Generally, the output signal can also be smoothened by the use of a parallel capacitance C.

Usually this circuit can be used as a burner monitor. If the UVtron electrodes are made with tungsten, which is resistant to large currents, the value of R_1 can be selected from 5 to 20 kΩ, which is very low as compared to that of a pulse driving circuit. Again if suitable values of R_2 and C are selected, a smoothened output signal of more than a few volts can be obtained, making the signal processing easier, as described later. For example, recommended circuit constants of R1868 and its output waveform are shown in Fig. 16(a) and (b).

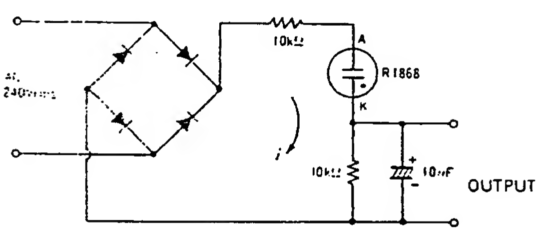


Fig. 16(a): Recommended circuit constants of R1868

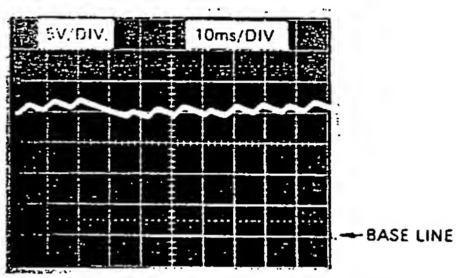


Fig. 16(b): Output waveform of R1868

2) RMS Voltage and Peak Voltage

When the UVtron is operated by pulsed voltage, the waveform of the voltage applied to the anode is shown in Fig. 17. An AC voltage is indicated by the root-mean-square voltage (Vrms) which is related to the actual voltage operation (peak voltage V_p) by the following expression:

$$V_P = \sqrt{2} \cdot V_{rms} \quad \text{..........(8)}$$

In general each characteristic value of UVtron is indicated in terms of DC voltage, which corresponds actually to the peak voltage V_p instead of the Vrms. Please keep this fact in mind when using AC or pulsed voltage.

For example, when R259 is used with DC voltage, the recommended applied voltage is 350 volts DC. When pulsed voltage is used, this value corresponds to:

$$350/\sqrt{2} \simeq 247 \; V_{rms}$$

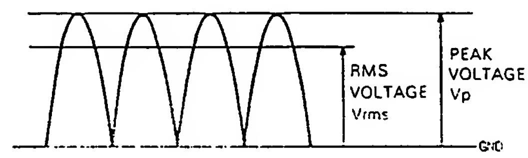


Fig. 17 RMS voltage and peak voltage

SENSITIVITY

UVtron is used within the glow discharge range as described in the operating principle section. In this range the current flowing through the UVtron for each discharge is determined by the external circuit and has nothing to do with the incident light intensity. Therefore, the sensitivity of UVtron does not depend on the discharge current, but depends on the number of discharges (number of pulses) when the quenching circuit is used. However, as discussed in the driving circuit section, the output pulse waveform and the saturation characteristics change according to the circuit type and the circuit constants. Therefore, the sensitivity can be expressed by a relative value under certain conditions.

Fig. 18 shows the sensitivity measurement method and the circuit diagram. Measurement is performed with monochromatic light of 200 nm which is the peak response wavelength of the UVtron.

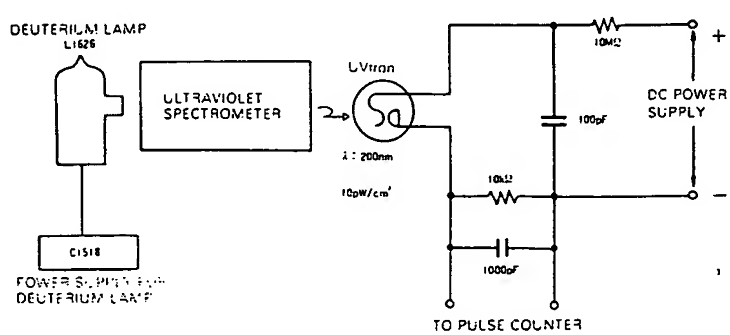


Fig. 18 Schematic diagram for sensitivity measurement of UVtron

1) Saturation Characteristic of Sensitivity

In the measurement system of Fig. 18, the number of output pulses is proportional to incident light intensity when the incident light is very weak. However, if the light intensity becomes large, the number of output pulses saturates. The number of output pulses at which the saturation occurs, f_{max}, depends on the quenching time t_q (which is determined by the circuit constant C_1, R_1) as follows:

$$f_{max} = 1/t_q \text{ (count/sec)} \ldots\ldots\ldots\ldots (9)$$

This is explained in Fig. 19. Since the sensitivity of UVtron should be measured within the good linear region below the saturation point, measurement is performed at a very low light level of 10 pW/cm² (at 200 nm).

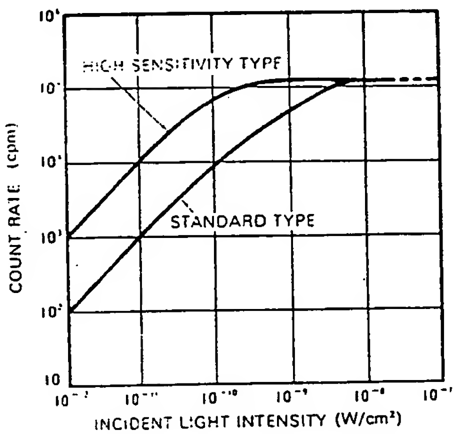


Fig. 19 Saturation characteristic of sensitivity

2) Applied Voltage and Sensitivity

Fig. 20 shows the relation between sensitivity and applied voltage of UVtron. The sensitivity rises with an increase of voltage along with an increase in "Background". Therefore, apply voltage should be within the recommended range. 250%

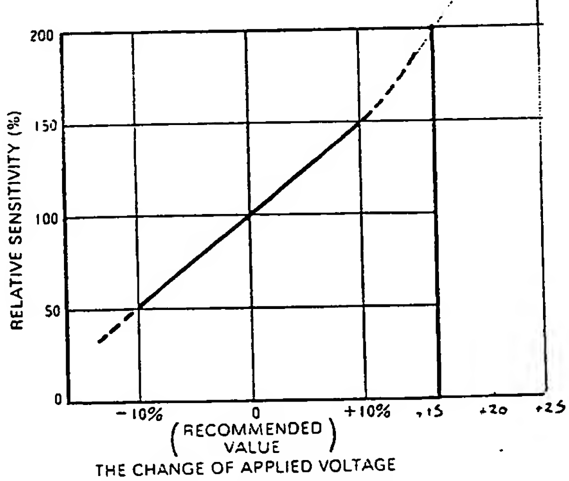


Fig. 20 Applied voltage and sensitivity

"Warning"

Sensitivity indicated in the characteristic table is a typical value measured under the conditions described above. However, the spectrum of ultraviolet light from the actual flames changes considerably according to the burning material and state of combustion.

Please consider "Sensitivity" as the selection criterion of the UVtron.

BACKGROUND

When voltage is applied to the UVtron, sometimes discharge takes place even without ultraviolet rays. This phenomenon is called "Background". The background discharge frequency changes considerably according to the applied voltage, intensity and type of background light, driving circuits, etc. Since the applied voltage is of great importance in this phenomenon, use the recommended value of applied voltage in order to design the apparatus with a good S/N ratio. Fig. 21 shows the relation between applied voltage and background discharge frequency. The reasons for the background phenomenon are listed below.

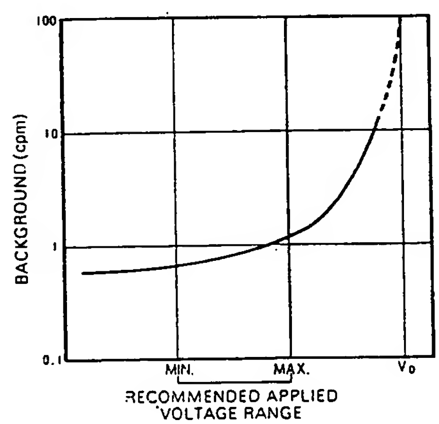


Fig. 21 Example of voltage-dependent background phenomenon

1) Radiation such as Cosmic Rays

In the case of normal use of UVtron, discharge occurs as a result of photoelectron being emitted from the cathode surface in response to ultraviolet rays. However, discharges can also take place due to beta or gamma rays.

2) Electronic Field Emission

When the applied voltage is high, electrons can be ejected from the cathode, and induce a discharge.

3) Ambient Light

The cutoff wavelength of UVtron is sharply defined only for pure metal and at absolute zero temperature. Actual cathode (containing a small amount of impurities, etc.) allows a residual electron photoemission at wavelengths beyond the cutoff wavelength. Therefore, a strong, direct incident light such as that from a fluorescent lamp may induce erratic discharge.

4) Static Electricity

If objects charged with static electricity are moved close to the UVtron or touch it, the gas inside the UVtron may become ionized by its high electric field and discharges may occur.

5) Ultraviolet Light from Extraneous Sources

The UVtron is supposed to detect ultraviolet rays regardless of their origin, so that ultraviolet rays from extraneous sources are likely to produce operational errors if they are icident on the UVtron's cathode. This can be considered as a background phenomenon. There are many varieties of ultraviolet source, more than we are aware of, especially when UVtron is used outside of a room. For example, sunlight, sparks from an ark welding unit or pantographs on a train, and other very weak ultraviolet light from unexpected sources are easily detected by UVtron. Therefore, please position the UVtron very carefully.

As previously explained, the background phenomenon is always present to some extent. Therefore, it is necessary to design a discriminating circuit for detecting signal (pulses due to ultraviolet rays from the flame of interest) in the presence of background at the signal processing stages, especially for fire alarm apparatus.

TEMPERATURE CHARACTERISTICS

Fig. 22 shows the change of various characteristic values of UVtron under ambient temperature variations. Within the temperature range of −20°C to +125°C, the discharge starting voltage, sensitivity, etc. are almost constant. But, because extinguishing time becomes long at temperatures less than −20°C, the discharge stopping voltage decreases slightly. Therefore, at very cold locations, it is necessary to sufficiently lengthen the quenching time of the driving circuit.

In addition, operating above +100°C can reduce the service life. If the ambient temperature is likely to become high, as in the case of burner monitoring, then air purge is required.

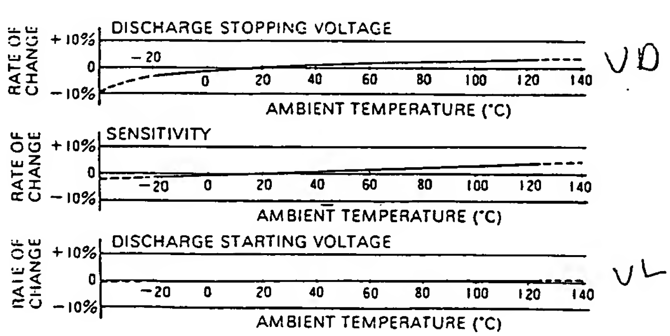


Fig. 22 Temperature characteristics of each parameter

SERVICE LIFE

When UVtron is used in the continuous discharge state, the characteristics given below undergo the following changes.

1. Change of discharge starting voltage V_L (when ultraviolet light is incident.)
2. Discharge stopping voltage V_D reduction
3. Sensitivity reduction

The general trend of change of above parameters is shown in Fig. 23

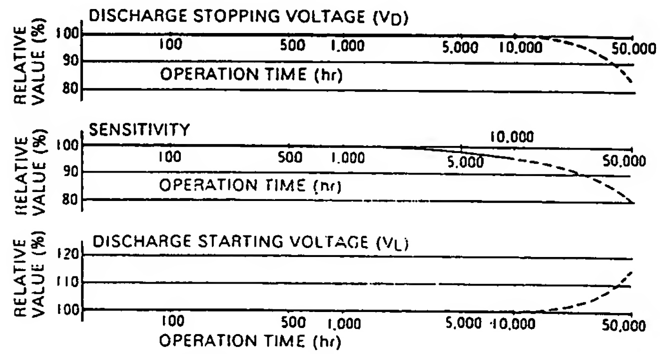


Fig. 23 Service life characteristics

These characteristics change due to the following reasons:

When the cathode receives the impact of positive ions during discharge, some of the atoms from the cathode surface matter are ejected and deposited on the anode and the wall of the bulb. This phenomenon is called "sputtering". The window and the bulb wall become darkened and their transmittance for ultraviolet rays decreases, resulting in a reduction of the sensitivity. Also, some amount of the enclosed gas is absorbed simultaneously. (This phenomenon is called "gas clean-up".) Therefore, the pressure of enclosed gas becomes lower, resulting in a change of V_L and V_D.

If any one of the following condition exists, it is considered that the UVtron service life has terminated.

1. When discharge starting voltage V_L changes by more than 20% of initial value.
2. When discharge stopping voltage decreases lower than the maximum applied voltage which is mentioned in the catalog.
3. When the sensitivity becomes lower than 50% of the initial value.

To extend the service life, it is important to reduce the discharge current. Please use an operating current lower than the recommended operating current given in the characteristic table. Also, bear in mind that the service life decreases if the ambient temperature rises.

Notice: The service life specified in the catalog corresponds to the recommended operating conditions.

PRECAUTIONS WHILE USING

1) UVtron emissions

When the UVtron discharges, it generates ultraviolet light by itself. Therefore, while using many UVtrons simultaneously, please arrange them in such a way so as to avoid their mutual interference.

2) Humidity

In the CR quenching circuits, which has a high resistance connected to the anode, proportionally important current leak may occur due to humidity near the lead wire of the UVtron, causing the anode applied voltage to decrease with a subsequent possible malfunction of the UVtron. Since the presence of dust and stains causes absorption of moisture, please keep the lead wire clean.

3) Window Stains

Since the UVtron operates at a high voltage, dust tends to collect on the surface of the glass bulb due to electrostatic attraction. This causes a reduction in the transmittance for ultraviolet rays and a decrease in sensitivity. Thus periodic cleaning is necessary.

4) Soldering

Some types of UVtron have flexible leads so that they may be soldered directly onto the printed circuit board. Other types have hard pins. If pins become hot, the glass bulb is likely to break or changes in its characteristics may occur. Therefore, please don't solder directly. Use a suitable socket for the UVtron.

5) Impact

All the UVtrons satisfy the impact endurance test (100G) of JIS C0921. However, if the UVtron is dropped or subjected to a severe shock, then the glass may break or the distance between the electrodes may be altered. This electrode distance has a major influence on the electric characteristics, so please bear this in mind and handle the UVtron carefully when using.

6) Polarity

UVtron has a cathode and an anode as discussed earlier. Please use the UVtron with respect to its polarity. if the connections are made improperly (by reversing polarity), the expected characteristics cannot be obtained.

SIGNAL PROCESSING AND APPLIED CIRCUITS

An example of the ultraviolet light detection apparatus using an UVtron is shown in Fig. 24. The driving circuit has been discussed already. Here, we describe the signal processing stage following the input interface.

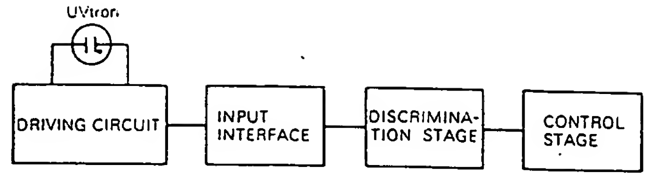


Fig. 24 The schematic block diagram of the ultraviolet light detection apparatus

1) Input Interface

The input interface should have a high input impedance so that it does not affect the quenching operation of the driving circuit. When the output signal from UVtron is in pulse form, the voltage amplification is not necessary. The impedance is changed through a C-MOS gate. If the peak voltage of the input pulse is too high, the voltage can be reduced by dividing R_2.

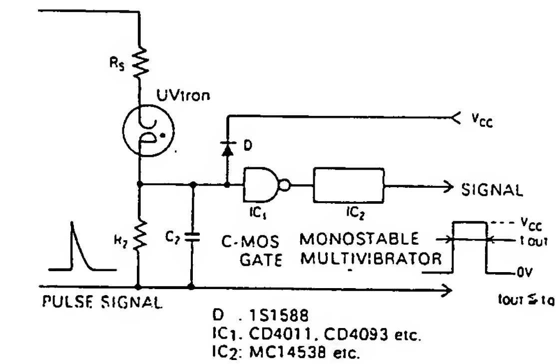


Fig. 25(a): Pulse signal input interface

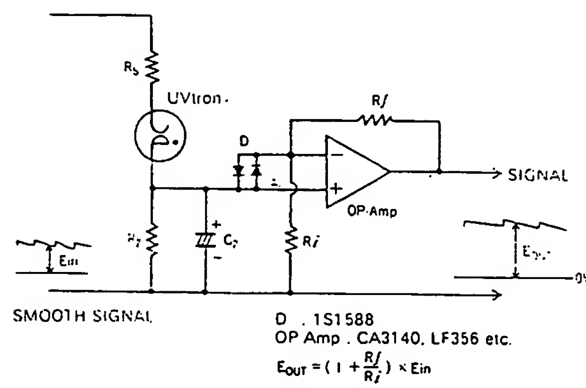


Fig. 25(b): Smooth signal amplifier circuit

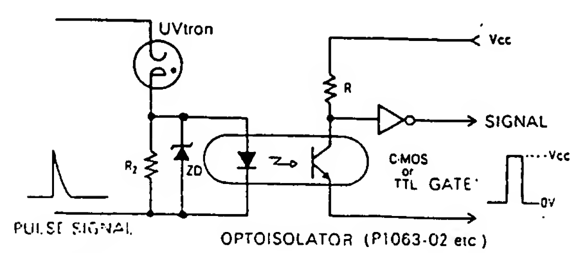


Fig. 25(c): Input circuit using a optoisolator

If a small capacitor C_2 (less than 100 pF) is connected across R_2, the peak can be lowered. If the width of the output pulse from C-MOS gate is amplified by monostable multivibrator IC, the signal processing becomes easier. If a large capacitor (greater than 10 μF) is connected in parallel to R_2, the output is transformed into a smooth DC voltage. In this case, output voltage is very low. Therefore, output voltage should be amplified using the non-reversible input of an operational amplifier. There is a method of isolating the driving circuit using an optoisolator.

These output circuits are shown in Fig. 25.

2) Discrimination Stage

After the input interface, it is necessary to discriminate whether a signal is due to ultraviolet light or noise (background). The basic concept is that if the number of discharges is very small (less than 3 to 5 cpm), it is evaluated as background noise. On the other hand, in the case of pulse output, if the number of pulses is greater than a specific number within a certain period, it is evaluated as the signal. In this case only, an output is sent to the control circuit.

This is shown in the time chart of Fig. 26.

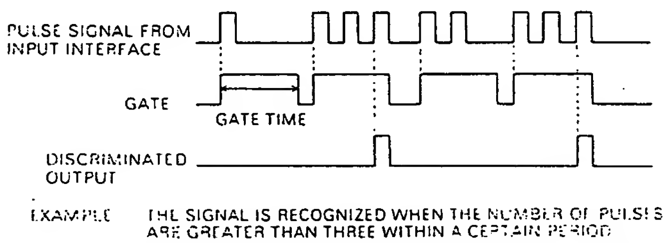


Fig. 26 Basic time chart of discrimination circuit

In this case, the sensitivity of the system as a whole (detection limit) is determined by the gate time and the predetermined number of pulses within this time. If the gate time is incresed, the accuracy of the discrimination increases, but the response time becomes longer. If we reduce the predetermined number of pulses, the sensitivity increases, but the risk of operational error also increases. In the case of voltage output using an operational amplifier, the discrimination can be achieved by using a comparator, as shown in Fig. 27. In this case, an output voltage is obtained only if E_{in} is greater than comparator voltage E_{ref}. In this circuit, the sensitivity can be adjusted by E_{ref}.

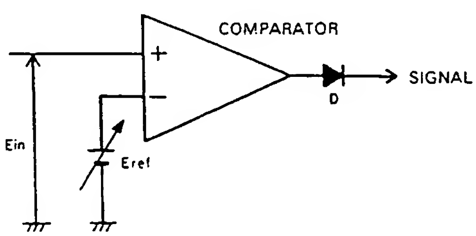


Fig. 27 Discrimation circuit of smooth input

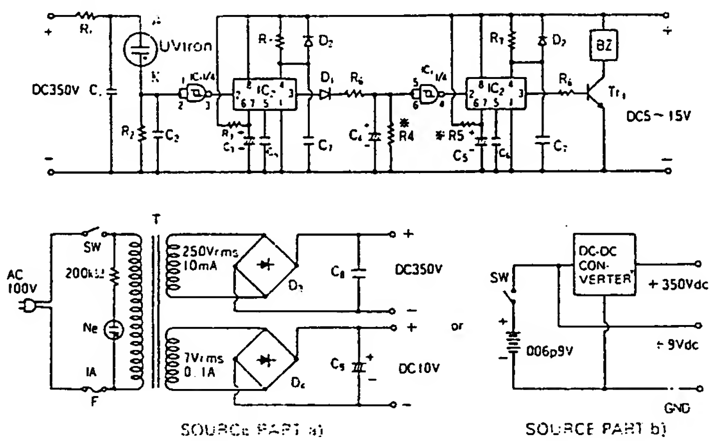
EXAMPLES OF APPLICATION CIRCUITS

1) Highly Sensitive Fire Alarm

This system makes use of R259. The sensitivity is very high. It can sense the flame of a cigarette lighter at a distance of 5 meters and can trigger a buzzer with unfailing reliability.

R_4·C_4 forms an integrating circuit which prevents operational errors and the sensitivity can be adjusted by the value of R_4. Please set the time from the lighting of the flame to the ringing of the buzzer at 0.5 second. The time required for the buzzer to stop after extinguishing the fire can be adjusted by controlling the value of R_5. For the parameters shown in the figure, this time lay is about 1 second.

Using the highly sensitive type of UVtron. R1753, the detectable distance can be extended to 10 to 15m.



UVtron	R259 (R1753)				
IC_1	C-MOS NAND GATE (CD4093B etc.)	R_1	20MΩ 1/2W	C_1	220pF 500V
IC_2	MONOSTABLE MULTIVIBRATOR IC (intel ICM7555)	R_2	10kΩ 1/4W	C_2	1000pF 50V
Tr_1	2 SC1815	R_3	300kΩ 1/4W	C_3	1μF 25V
D_1, D_2	1 S1577	R_4	500kΩ 1/4W	C_4	10μF 25V
D_3	S 1 VB60	R_5	1MΩ 1/4W	C_5	1μF 25V
D_4	S 1 VB10	R_6	47kΩ 1/4W	C_6	0.01μF 50V
BZ	BUZZER SMB − 12 (STAR)	R_7	1MΩ 1/4W	C_7	0.1μF 50V
				C_8	0.1μF 500V
				C_9	1000μF 25V

Fig. 28 Highly-sensitive fire alarm

2) High Sensitivity Relay Circuit

This is a highly-sensitive relay circuit using an R334 and an operational amplifier. The detector sensitivity can be adjusted by R_f.

For the parameters shown in the figure, the gain is 100. Therefore, an offset adjustment (10kΩ VR) of the operational amplifier should be made. The reset time of the relay can be adjusted by C_2·R_2.

HAMAMATSU

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How to use UV TRON®

HAMAMATSU

ATTACHMENT 4

The UV TRON is a sensor which is sensitive only to ultraviolet rays with a wavelength of 260nm or less. Featuring high sensitivity, high output, and high-speed response, this is the optimum sensor for flame detection and perception of electrical discharge phenomena.

FEATURES

- Capability of detecting very weak ultraviolet rays (from 1 pW)
- Not sensitive to visible and infrared light (solar blind characteristics)
- High reliability and long life (over 10,000 hours of continual discharge operation)
- High speed response (less than a few milliseconds)
- Miniature size and lightweight

APPLICATIONS

- Flame detectors for gas/oil lighters and matches
- Combustion monitoring apparatus for gas/oil burner
- Fire alam apparatus
- Photoelectric counter
- Detection of ultraviolet ray leakage
- Detection of discharge phenomenon

Fig. 1 shows the spectral radiant intensity of a gas burner flame, a tungsten lamp, and the sunlight on the earth's surface and the spectral response of UV TRON. From this figure, we can see that UV TRON sensitivity is restricted to a very narrow region of ultraviolet rays, and exhibits no response at all in the visible region.

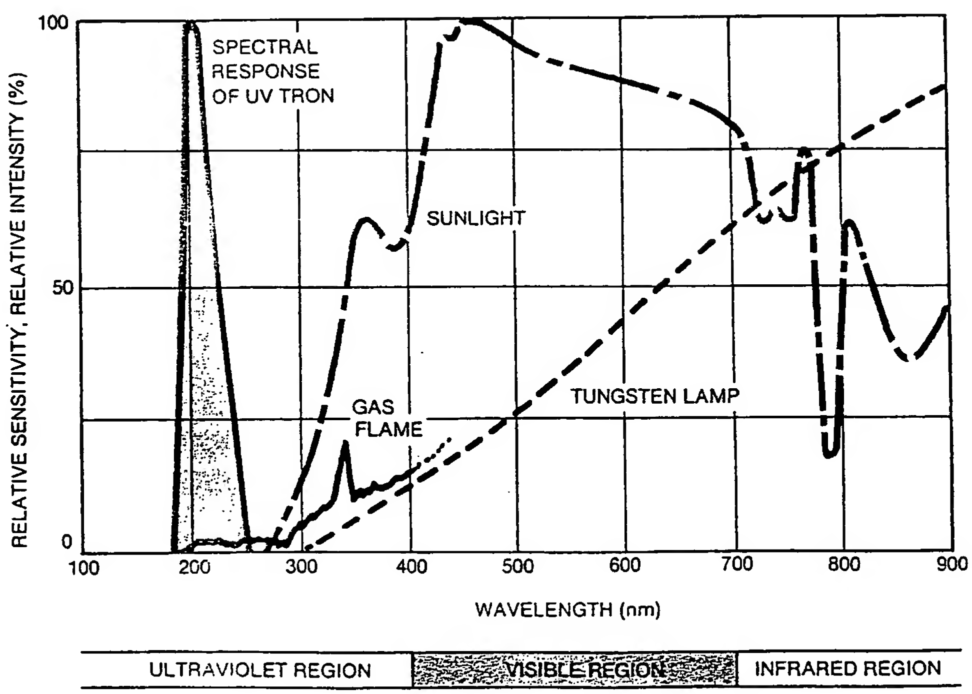


Figure 1: Various Types of Spectral Radiant Intensity

STRUCTURE AND BASIC PRINCIPLES OF OPERATION

The UV TRON is a bipolar tube with a structure similar to that of a phototube. Just as a phototube, a UV TRON uses the photoelectric emission effect, but the inside of the UV TRON tube is filled with a special gas rather than being a vacuum, so it operates as a discharge tube. Fig. 2 shows its structure and models its operation. Voltage is applied between the photocathode, which is only sensitive to ultraviolet rays, and the anode. When UV rays pass through the UV glass and strike the cathode, electrons (photoelectrons) are emitted from the surface of the cathode due to the photoelectric emission effect. These are drawn to the anode by the electrical field created by the applied voltage. When the voltage is low, the operation is the same as for a phototube and the current i is extremely weak. If the voltage is increased to strengthen the field, the photoelectrons are accelerated, so they collide with the gas molecules within the tube and ionize those molecules. The photoelectrons continue to collide with gas molecules until they finally reach the anode. The positive ions thus generated are accelerated towards the cathode and the resulting collisions generate secondary electrons. As this cycle is repeated, a large current is rapidly generated between the anode and the cathode and electricity is discharged. This phenomenon is called gas multiplication and the voltage at which this discharge starts is called "the discharge starting voltage (V_L)" of the UV TRON.

Once the electrical discharge has begun, the tube is filled with electrons and ions and the voltage drop across the cathode and anode is much lower than before the discharge began. Fig. 3 shows this state. The UV TRON primarily operates in the glow discharge region, but in this region since the tube drop voltage Vs is lower than the discharge starting voltage V_L, the discharge will continue unless some device is introduced to the applied voltage. ⇒ This device is called a Quench Circuit F.G 12/28/05

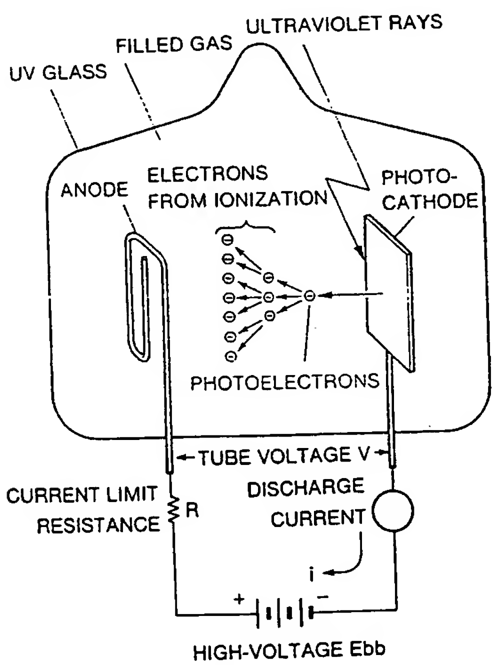


Figure 2: UV TRON Operation

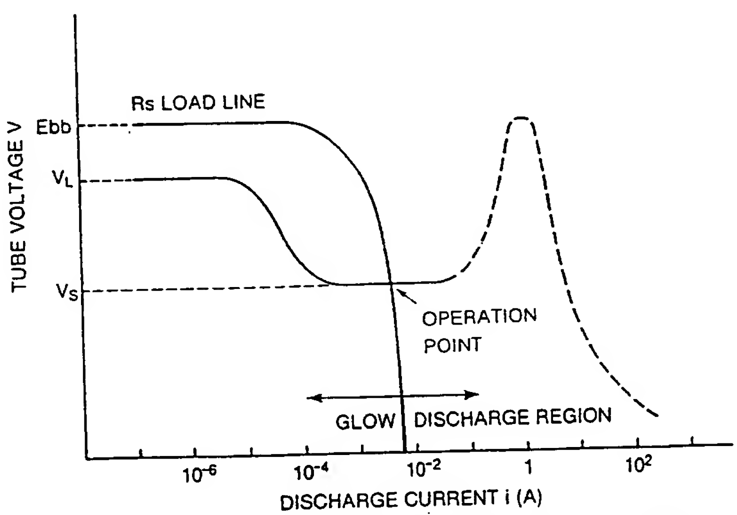


Figure 3: V-I Characteristic of the UV TRON

UV TRON DRIVE CIRCUIT

Driving the UV TRON requires a high voltage of about 350 V. Fig. 4 shows the basic circuit for the DC-DC converter high-voltage power supply and the operating waveforms for each part. In this case, it is important to lower the frequency f of the converter oscillation, to reduce the capacitance of the capacitor C_1 for smoothing the rectified high voltage, and to raise the power supply's output impedance. Here is an explanation of the operation of this circuit.

Point ⓐ: This is the converter's oscillation wave. A pulse with a width of a few μs is generated at intervals of from a few ms to a few tens of ms.

Point ⓑ: The height of the pulse is raised in proportion to the winding ratio for the voltage boost transformer.

Point ⓒ: High DC voltage Ebb is applied to the anode of the UV TRON by rectification diode D and smoothing capacitor C_1.

Point ⓓ: When ultraviolet radiations reach the UV TRON, it begins to discharge. The discharge current i is supplemented by the charge on C_1 to generate narrow voltage pulses across R and C_2.

Point ⓔ: The charge on C_1 is exhausted, the anode voltage falls below the tube drop voltage, Vs, and the discharge stops. The anode voltage does not recover until the next charge. During that period, the ions in the UV TRON are quenched. (They disappear.)

Point ⓕ: If no ultraviolet radiation reaches the UV TRON, the anode voltage recovers to Ebb, but there is no discharge until ultraviolet radiation is received.

The UV TRON repeats this cycle to indicate the presence or absence of ultraviolet radiation with pulse signal output. Here, it is important that the converter oscillation interval (1/the oscillation frequency f) be greater than the time required for the ions generated in the UV TRON tube by the discharge to be quenched, so this interval must be from 5-10 ms. This period is called the quenching time. Also, since the capacitance of smoothing capacitor C_1 influences the discharge current, in order to retard the wear on the electrodes and to reduce the number of ions generated, it is best to reduce the capacitance of C_1. The optimum capacitance is a few tens of pF.

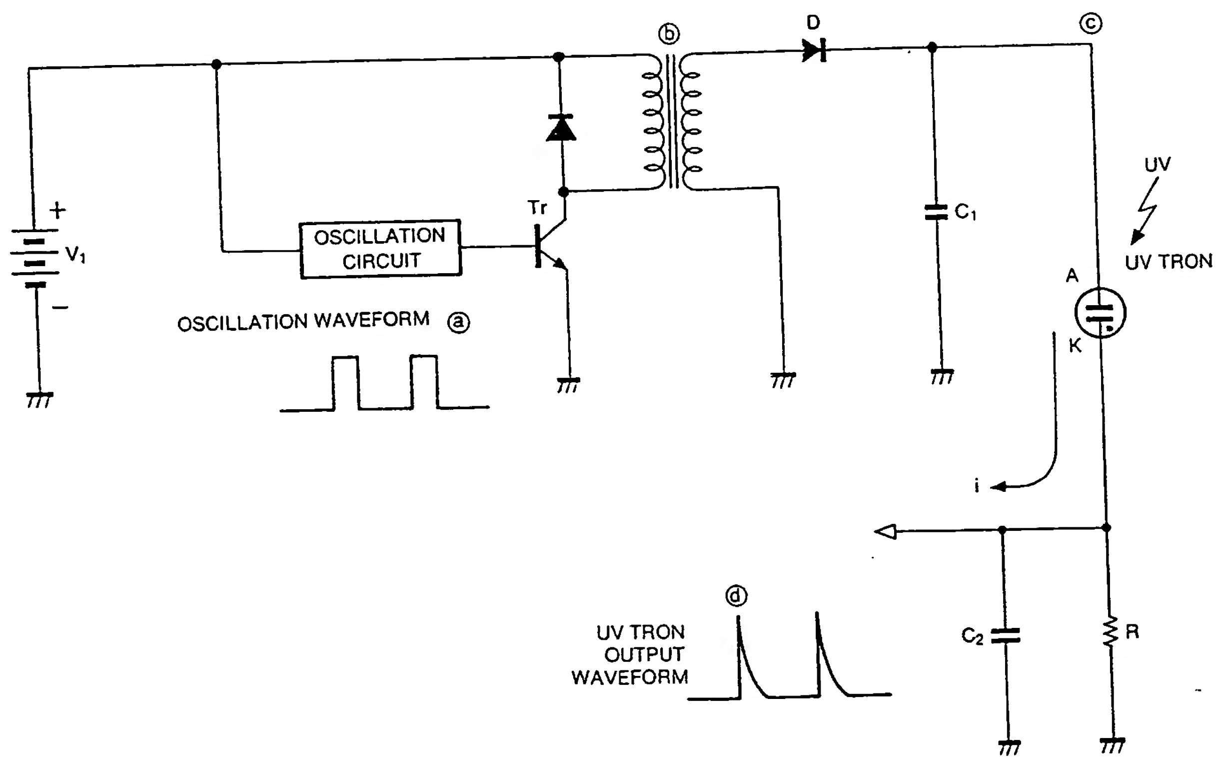


Figure 4a: UV TRON Drive Circuit

SELECTION GUIDE

UVtron can detect very weak ultraviolet light without fail. It has the following two applications.

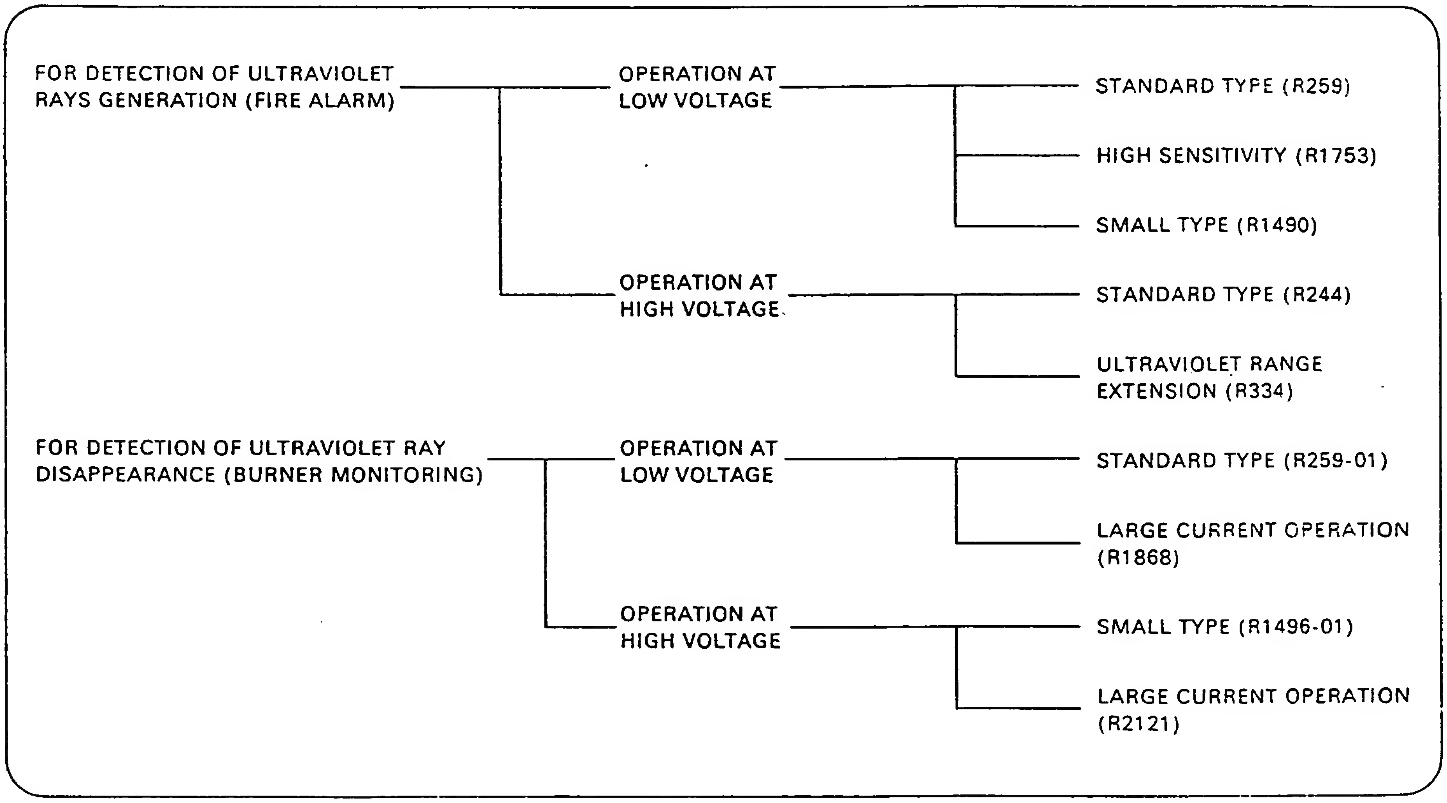
1) Application for use in fire alarm and discharge detectors by utilizing UVtron's capability of detecting ultraviolet rays.

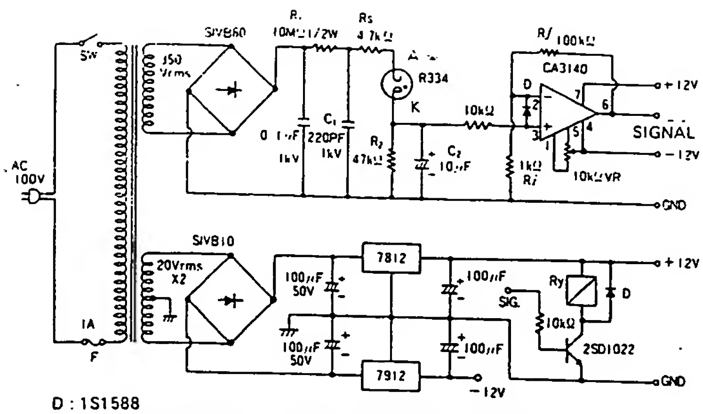
2) Application for use as a combustion monitor apparatus to detect the disappearance of ultraviolet rays.

In the first application, the UVtron is usually not in the discharge mode, but discharge only under abnormal conditions. Such discharges may be triggered under conditions exhibiting solar blind characteristics, high sensitivity, and low background.

In the second application, the UVtron is usually in the discharge mode, but the discharge stops only under abnormal conditions. In this case, electrodes featuring high resistance against sputtering are needed, due to self-maintained discharge etc.

Hamamatsu Photonics has designed and made UVtrons for various applications. Please select the most suitable UVtron according to the following selection guide.





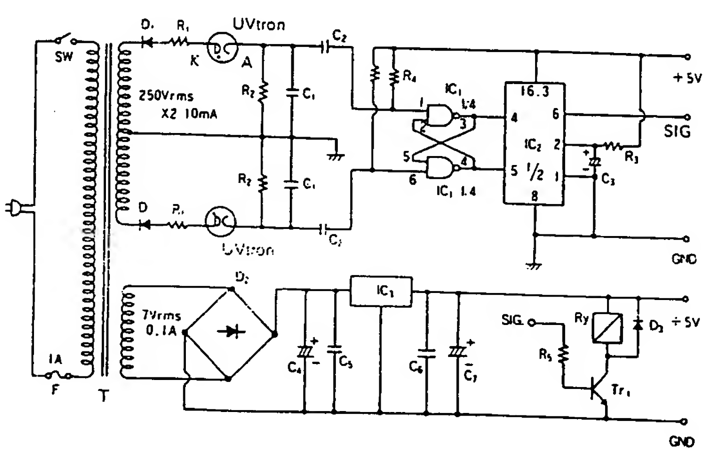
D : 1S1588
UNSPECIFIED RESISTOR : 1/4W, UNSPECIFIED CAPACITOR : 25V

Fig. 29 High sensitivity relay circuit
(using operational amplifier)

3) High Reliability Relay Circuit:

This circuit makes use of two UVtrons which discharge alternately according to line frequency so that there is no optical interference between the two. The flip-flop circuit is operated by the trigger signal and the relay is driven by the multivibrator. Using such a circuit, if one of the UVtrons fails, the circuit accurately senses the event to be detected. The reset time of the relay can be adjusted by the time constant ($R_3 \cdot C_3$) of the monostable multivibrator circuit. If a flame flutter, a sudden flame appearance or disappearance, combustion instabilities due to blockage of the burner tube, or flame fluctuations occur the next relay circuit delays its response then operates after a time lay of a seconds. For this purpose a delay circuit has been designed.

The response is 0.1 to 0.2 seconds, if the ultraviolet light is incident. This is useful for burner monitoring apparatus.



UVtron : R259 − 01, R1868
IC₁ : C-MOS NAND GATE (CD4011 etc.)
IC₂ : MONOSTABLE MULTIVIBRATOR IC (MC14538)
IC₃ : REGULATOR IC 5V 1A (μA7805)
Tr₁ : 2 SD1022
D₁ : S1V60
D₂ : S1VB10
D₃ : 1S1588

R₁ : 470kΩ 1/2W
R₂ : 47kΩ 1/4W
R₃ : 2MΩ 1/4W
R₄ : 47kΩ 1/4W
R₅ : 47kΩ 1/4W

C₁ : 1000pF 50V
C₂ : 0.1μF 50V
C₃ : 1μF 25V
C₄ : 100μF 25V
C₅, C₆ : 0.1μF 50V
C₇ : 100μF 25V

Ry : RELAY

Fig. 30 High reliability relay circuit:

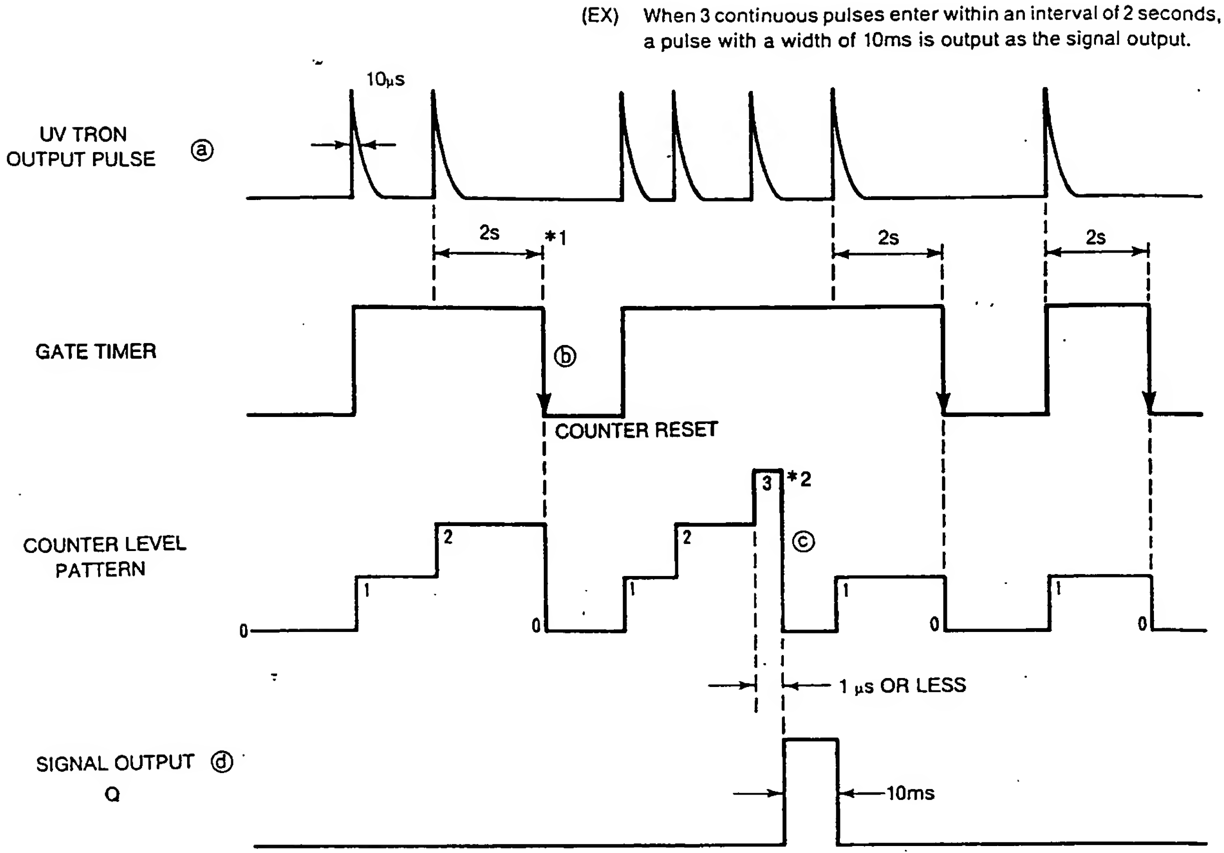


Figure 8: Signal Processing Circuit Operation Timechart

APPLIED VOLTAGE AND SENSITIVITY

Fig. 9 shows the general relationship between the applied voltage and the sensitivity for the UV TRON. The UV TRON is more sensitive if the applied voltage is higher, but this also increases the background noise, so please keep the applied voltage within the recommended range.

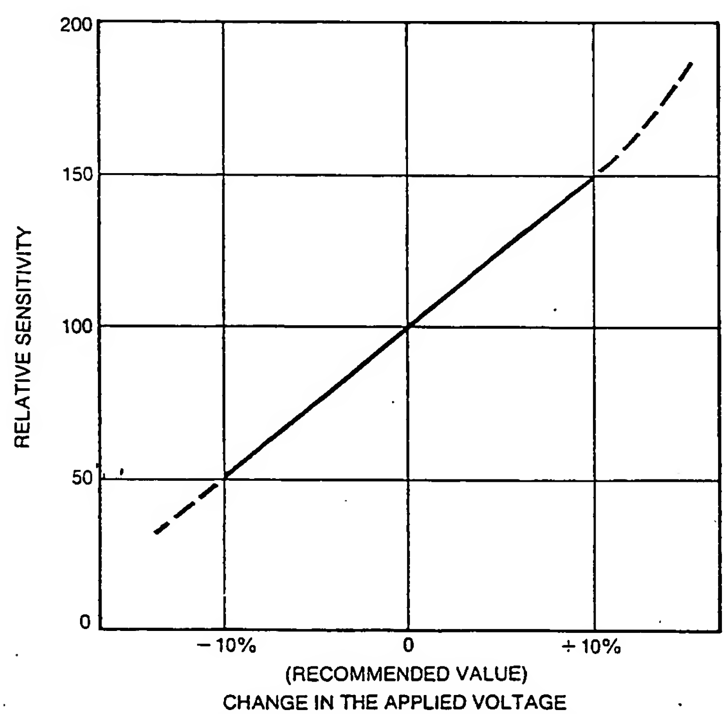


Figure 9: Applied Voltage and Sensitivity

PRECAUTIONS FOR USING THE UV TRON

① UV TRON light emission

When the UV TRON discharges, it emits ultraviolet radiation. If a number of UV TRON are used in close proximity, they must be arranged so that they will not interfere with each other optically.

② Humidity

Humidity around the leads for the UV TRON generates leak current, dropping the anode voltage, and stopping the tube from operating. In particular, if dirt, dust etc. get on the leads, that makes it easier for humidity to be absorbed, so keep the area around the leads clean.

③ Dirt on the window

Since the UV TRON operates at high voltage, static electricity causes dust to build up on the surface of the glass bulb. This invites lowering of the ultraviolet transmissivity and sensitivity of the UV TRON, so periodic maintenance, such as wiping off with gauze dipped in alcohol, is necessary.

④ Soldering

For mounting the UV TRON on a printed circuit board, solder it quickly (300°C for less than 5 seconds). If the leads are heated excessively, the glass can crack or the characteristics of the UV TRON deteriorate. After soldering, wipe away the solder flux with alcohol or a similar agent. If the leads are left dirty, current leak due to humidity will lower the voltage applied to the UV TRON, and it may not operate. When using UV TRON with hard pins, use the UV TRON socket available from HAMAMATSU.

⑤ Vibration and shock

The UV TRON is designed in accordance with the standards of MIL-STD-202F (Method 204D/0.06 inch or 10g, 10-500Hz, 15 minutes, 1 cycle) and MIL-STD-202F (Method 213B/100g, 11ms, Half-sine, 3 times). However, should a strong shock be sustained by the UV TRON (e.g. if dropped), the glass bulb may crack or the internal electrode may be deformed, resulting in deterioration of electrical characteristics. So extreme care should be taken in handling the tube.

⑥ Polarity

The UV TRON has a cathode and an anode, so connect these electrodes correctly. Reversing the electrode connection causes faulty operation.

HAMAMATSU

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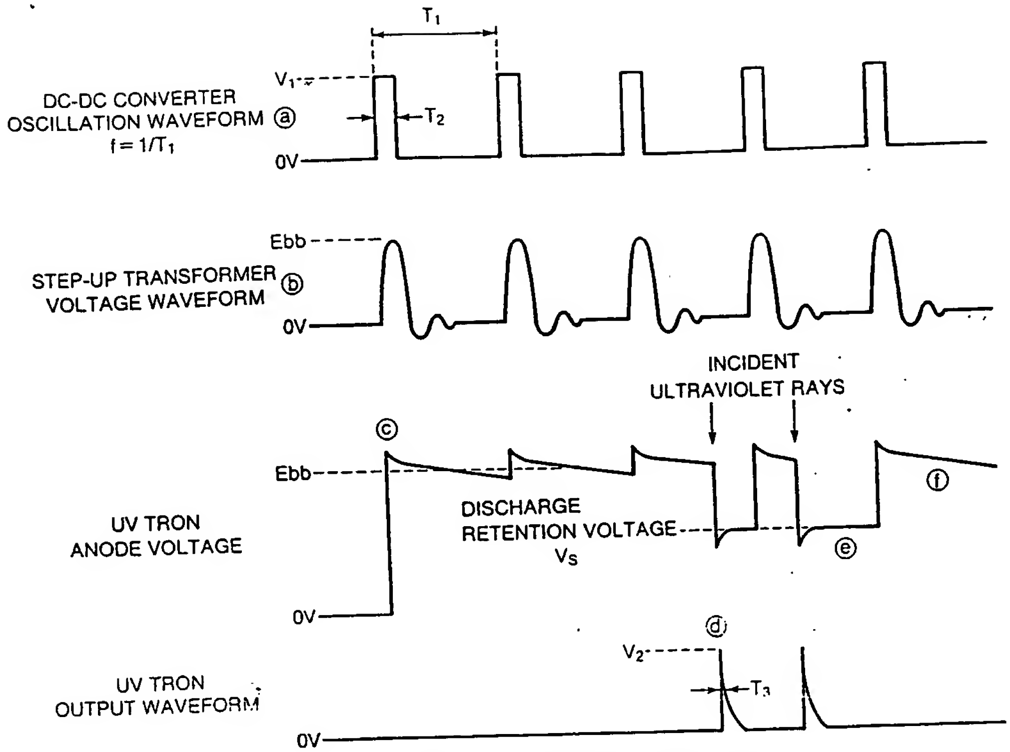
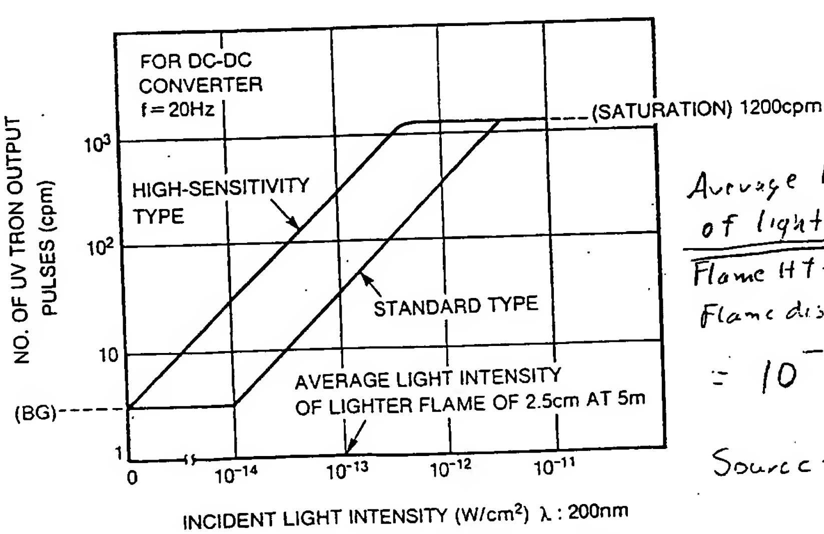


Figure 4b: Operation Waveform

SIGNAL PULSES AND BACKGROUND

When the UV TRON is operated with the circuit shown in Fig. 4a, the number of output pulses is increased in proportion to the intensity of incident light but there is saturation at the converter's oscillation frequency f. Fig. 5 and 6 shows this state. The UV TRON is better for on-off signalling than for precise light measurement of light volumes. The next point that must be noted is the background noise (BG). What "background noise" means is that even if the UV TRON receives no ultraviolet radiation, there is sporadic discharge due to such factors as cosmic radiation and static electricity. Fig. 6 also shows this. When detecting ultraviolet radiation with the UV TRON, if the output pulses are used directly as the detection signals, the background noise will cause mistaken operation. Therefore, the signal must be processed to cancel out this background noise.



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Average light Intensity of lighter Flame

Flame Ht = 2.5cm ≈ 1 inch

Flame distance = 5m = 16.4 ft

$\approx 10^{-13}$ w/cm^2

Source = 250 pw/cm^2 @ 200nm

Figure 5: Sensitivity and Background of the UV TRON

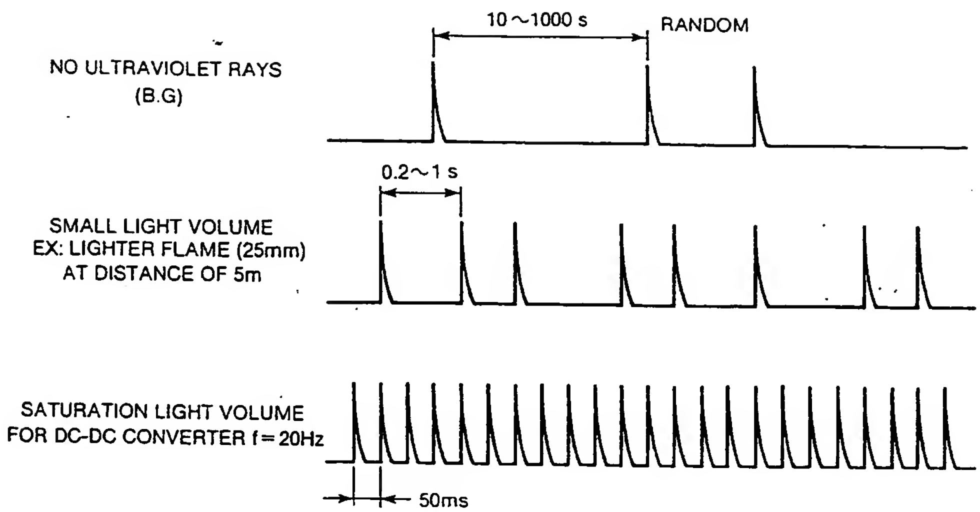

Figure 6: UV TRON Output Pulse

SIGNAL PROCESSING CIRCUIT

Since the UV TRON output pulse waveforms are the same for incident ultraviolet radiation and for background noise, the waveforms can not be distinguished. Therefore, the pulse generation frequency (the interval between pulses) is used to cancel out the background noise. Fig. 7 is a block diagram for the signal processing circuit and Fig. 8 is a timing chart for its operation. Here is an explanation of the operation of this circuit.

Point ⓐ: The output pulses from the UV TRON are input to the gate timer and the counter at the same time. The counter counts the pulses.

Point ⓑ: If the pulses continue to enter with an interval shorter than the value set for T_1, the gate timer maintains the open state, but if the pulse interval is greater than T_1, the gate timer closes the gate and resets the counter.

Point ⓒ: If a series of pulses are input, the counter adds them up. When it reaches the set value, it generates a pulse in the output circuit and resets the counter.

Point ⓓ: At the output circuit, the output pulses are lengthened to the necessary interval (T_2) and output.

*1 It is important to set the value of T_1 lower than the interval at which background noise pulses are generated. It is usually safe to set it to 5 seconds or less. If the interval is set too short, weak ultraviolet radiation can not be detected.

*2 The sensitivity of the device is determined by the counter setting. To trigger the device with weak ultraviolet radiation, set the counter to 10 or less. To have the device only detect higher intensity of ultraviolet radiation, or to have the device operate for weak ultraviolet radiation if it is received for a prolonged period, set the counter value to more than 10. If the counter value is set to 3 or less, it may not be possible to cancel out the background noise, so avoid this.

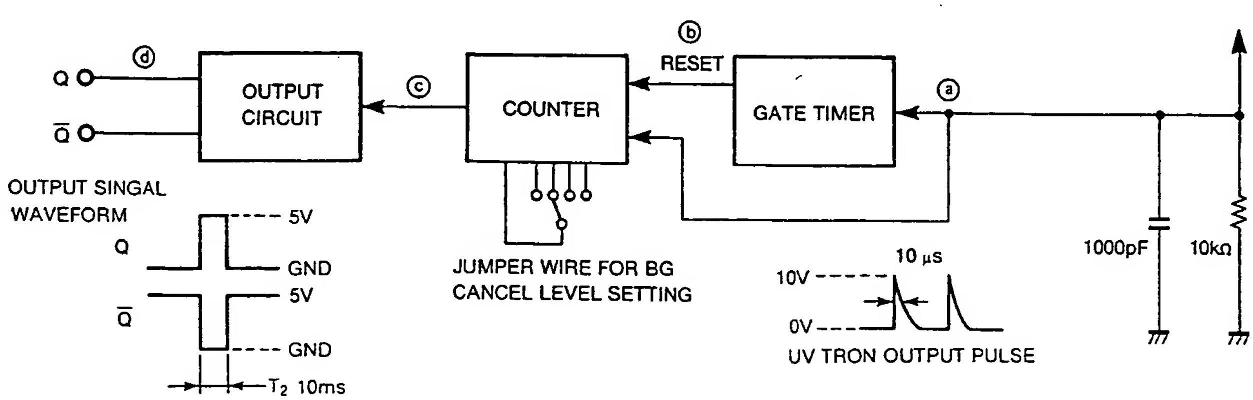

Figure 7: Signal Processing Circuit